

Studiehandleiding

Simulatie teamtraining voor zorgprofessionals betrokken bij de opvang van een neonaat in het Streekziekenhuis Koningin Beatrix

2019



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Inleiding

De opvang van een neonaat in een vitaal bedreigde situatie vraagt om specialistische zorg en ondersteuning van een inter-professioneel team. Het toepassen van Crisis Resource Management (CRM) is een goede methode om samenwerking en communicatie in een team te optimaliseren met als doel het verhogen van de patientveiligheid en het verbeteren van de kwaliteit van de geleverde zorg.

In nauwe samenwerking met mevrouw Saskia van Daalen (kinderarts) en mevrouw Marieken Vos (team manager) van het Streekziekenhuis Koningin Beatrix is voor u een training ontwikkeld, waarbij CRM aspecten in een inter-professioneel team centraal staan. Mevrouw Marije Hogeveen (kinderarts-neonatoloog) en heer Tim Antonius (kinderarts-neonatoloog) van het Radboudumc zijn experts op het gebied van simulatie onderwijs en zullen deze training voor u verzorgen.

Toepassing van de CRM principes in de context van de dagelijkse beroepspraktijk zal expliciet worden behandeld in de training. Deze principes gelden altijd en overal en zijn dus niet enkel van toepassing op geselecteerde specialismen. De nadruk zal wel vooral worden gelegd op de acute setting, omdat in die situaties de kernpunten van CRM onder een vergrootglas komen te liggen.

De volgende onderwerpen komen aan bod:

1. Het primaire doel van CRM;
2. De 15 kernpunten van CRM met per punt een praktische vertaling naar de praktijk;
3. De 15 kernpunten in een breder kader zoals aangeboden in nascholing in het Radboudumc;
4. Het geven en ontvangen van feedback;
5. NLS algoritme.

De onderwerpen worden u ter voorbereiding in deze reader aangeboden in de vorm van artikelen; video's welke u op youtube kunt bekijken en zelfstudieopdrachten. De Engelse artikelen in deze reader zijn voor de **verpleegkundigen** optioneel behalve het artikel van Rall&Diekman (*Crisis Resource Management to improve patient safety*). Dit artikel raden wij ook verpleegkundigen aan te lezen.

Op de trainingsdag door middel van scenario training. Ook zult u worden gevraagd te reflecteren op uw eigen situatie, ter voorbereiding op de discussie met uw collega's. Tijdens de trainingen op locatie zullen scenario's, specifiek geschreven om bepaalde CRM-kernpunten uit te lichten, dienen als verdere verdieping van het cursusmateriaal.

De training bestaat uit drie onderdelen:

1. zelfstudie aan de hand van de literatuur en opdrachten in deze reader.
2. een simulatie team training op locatie Winterswijk onder begeleiding van 1 gecertificeerde arts simulatie instructeur en een operator.
3. Met verbeterpunten aan de slag in de praktijk.

Deze combinatie is belangrijk om tot optimaal leren te komen. Tijdens de training wordt gebruik gemaakt van de voorbereiding die door iedereen is gedaan.



Leerdoelen:

- De deelnemer voert in een oefensituatie de neonatale life support inclusief de bijbehorende technische vaardigheden volgens de guidelines 2015 uit.
- De deelnemer heeft inzicht in eigen sterke punten en verbeterpunten op het gebied van samenwerken en communicatie in een team, zoals:
 - Elkaar aan durven spreken.
 - Het bespreekbaar maken van conflicten.
 - Gebruik maken van alle kwaliteiten in een team.
 - Bijdragen aan een goede taakafstemming en communicatie in het team.
 - Leiding nemen en leiding (laten) nemen als de situatie dit vereist, ongeacht hiërarchie.
 - Effectief gebruik maken van alle, in het team en op de werkplek, aanwezige informatiebronnen (teamleden, patiënt, apparatuur en ondersteunende faciliteiten) om veilig en efficiënt op te kunnen treden.

Opbouw van de reader

Deze reader is als volgt opgebouwd:

1. Programma
2. Verplichte literatuur met afwisselend filmpjes en opdrachten. In totaal zijn er 4 opdrachten.

Wij wensen u veel succes en plezier toe tijdens de training!

Marije Hogeveen
Kinderarts-neonatoloog
Radboudumc Amalia kinderziekenhuis

Tim Antonius
Kinderarts-neonatoloog
Radboudumc Amalia kinderziekenhuis

Jacqueline van Tricht
Opleider
Radboudumc Health Academy
April 2019



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Programma

Arts instructeurs:

- Drs Tim Antonius; kinderarts-neonatoloog

Operator:

- Theo Peeters; verpleegkundig specialis afdeling neonatologie

Datum/tijd: 17 juni 2019 van 9.00 – 13.00 uur

Locatie: SKB Winterswijk, VrouwKind afdeling (afd. F0). Kamers 23-21-16.

Ochtend sessie:

Tijd	Onderdeel
9.00 – 9.30	Welkom en kennismaken. <i>Door: Tim Antonius</i>
9.30 – 9.45	Vragen vanuit de voorbereiding <i>Door: Tim Antonius</i>
9.45 – 10.00	Familiarisatie <i>Door: Theo Peeters</i>
10.00 – 10.45	Scenario 1
10.45 – 11.00	Pauze
11.00 – 11.45	Scenario 2
11.50 – 12.35	Scenario 3
12.35– 13.00	Evaluatie en afsluiting

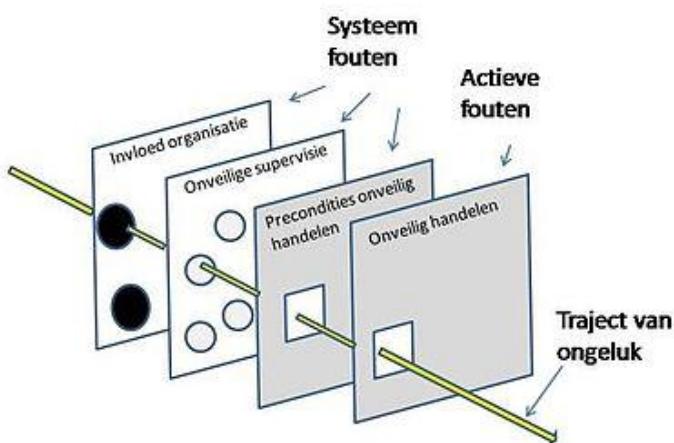


Hoofdstuk 1: Introductie in de Crew Resource Management (CRM)

Zorg voor patiënten in acute situaties vormt een aparte uitdaging voor zorgprofessionals. Werken onder tijdsdruk in vaak complexe en onzekere situaties kan het risico op het maken van fouten vergroten. Wanneer in deze setting inderdaad fouten worden gemaakt, zijn deze veelal niet te wijten aan inadequate medische kennis, maar aan de omstandigheden die het vertalen van deze kennis naar de klinische praktijk bemoeilijken. Crew Resource Management (CRM) richt zich op het zo optimaal mogelijk laten verlopen van deze vertaalslag. Het kent haar oorsprong in de luchtvaart en vond via de anesthesiologie een opening naar de medische beroepspraktijk.

Definitie van CRM: *het effectief gebruik maken van alle, in het team en op de werkplek aanwezige informatiebronnen (teamleden, apparatuur en ondersteunende faciliteiten) teneinde veilig en efficiënt op te kunnen treden.*

In 1990 werd door psycholoog James T. Reason een model ontworpen waarmee werd getracht het optreden van calamiteiten binnen organisaties te verklaren. Dit Zwitserse kaas model laat zien hoe op verschillende niveaus binnen een organisatie fouten kunnen worden gemaakt. Wanneer deze (veelal nog kleine en relatief onschuldige) fouten zich opeenvolgend voordoen, wordt het pad (risicotraject) geplaveid voor een calamiteit.



Bij de meeste calamiteiten is er sprake van falen op al deze niveaus. CRM richt zich primair op de zogenaamde human factors, het handelen van individuen, de vierde laag, maar beoogt daarnaast ook veranderingen in organisaties na te streven waardoor mensen minder in de gelegenheid worden gesteld om fouten te maken.

Het primaire doel van CRM is om alle beschikbare bronnen zo in te zetten dat de patiëntveiligheid wordt geoptimaliseerd. Onder deze bronnen worden alle betrokken hulpverleners verstaan, met stuk voor stuk hun eigen vaardigheden, attitudes en tekortkomingen, maar daarnaast ook de eventueel te gebruiken materialen en/of apparatuur. CRM begint idealiter al voordat de calamiteit optreedt.

Opdracht 1:

Bekijk de video "[Just a routine operation](#)" waarin Martin Bromily, aan de hand van een reconstructie, vertelt over het overlijden van zijn echtgenote na een 'routine' ingreep. De video duurt ongeveer 13 minuten. Houdt pen en papier bij de hand en noteer zaken die u gedurende de video opvallen.

Welke oorzaken of bijdragende factoren ziet U op het gebied van communicatie?



Artikelen bij hoofdstuk 1

Lees onderstaande artikelen in de bijlage.

Let op: voor verpleegkundigen geldt betreffender de Engelse artikelen → alleen het artikel van **Rall&Diekman** is verplicht. De overige Engelse artikelen zijn optioneel.

- Artikel: Wyllie&Urlesbergen
**European Resuscitation Council Guidelines for resuscitation 2015 section 7.
Resuscitation and support of transition of babies at birth.**
- NLS algoritme 2016
- Artikel Rall&Diekman
Crisis Resource Management to improve patiënt safety.



Hoofdstuk 2: Belangrijkste punten uit de CRM

Nu U het artikel van Rall&Diekmann heeft gelezen zetten we hieronder de belangrijkste punten van CRM op een rijtje.

1. Ken je werkomgeving (mensen, materiaal, logistiek)
2. Anticipeer en plan
3. Roep bijtijds om hulp
4. Wijs leiders en volgers aan
5. Verdeel de werklast
6. Maak gebruik van alle mogelijke hulp
7. Communiceer effectief
8. Gebruik alle beschikbare informatie
9. Voorkom fixatiefouten
10. Cross (double) check
11. Gebruik cognitieve hulpmiddelen
12. Herevalueer herhaaldelijk
13. Gebruik goed teamwerk
14. Richt uw aandacht weloverwogen
15. Vergeet niet uw prioriteiten bij de stellen

Hieronder zijn in een cirkel belangrijke elementen uit CRM weergegeven:



2.1 Informatie management

Met informatiemanagement wordt zowel het omgaan met de diverse beschikbare informatiebronnen, als de informatie die hier vervolgens uit verkregen wordt, bedoeld. Hieronder vallen bijvoorbeeld het elektronisch patiëntendossier, verwijsbrieven van de huisarts en de mondelinge overdracht van uw collega's. Al deze informatie samen vormt de basis voor de wijze waarop u een situatie interpreteert.

2.2 Communicatie

Heldere communicatie is essentieel, des te meer in crisissituaties. Een goede samenwerking wordt onder meer bevorderd door een gezamenlijke visie. Wanneer door heldere en eenduidige communicatie alle betrokken hulpverleners op één lijn zitten wat betreft de actuele situatie (*situational awareness*), dan zal de samenwerking stukken beter verlopen. Bij verlies van *situational awareness* van het team kan een time out, meestal geïnitieerd door de teamleider, uitkomst bieden. Sprek daarnaast mensen direct aan bij het geven van een opdracht, het liefst bij naam. Bevestig dat wanneer u een opdracht krijgt, u de opdracht heeft gehoord en begrepen en koppel het terug met de teamleider wanneer de taak is uitgevoerd. Deze manier van communiceren noemen we *closed loop communicatie*.

Voor het structureren van de medische overdracht (zowel bij persoonlijk als telefonisch contact) zijn diverse hulpmiddelen ontworpen. In box 1 ziet u een voorbeeld van de vaak gebruikte SBAR en RSVP methoden. Door op gestandaardiseerde wijze over te dragen wordt voorkomen dat belangrijke zaken worden vergeten en wordt de luisteraar geholpen in het opnemen van de informatie. U spreekt als het ware 'dezelfde taal'.

U ziet dat een dergelijke overdracht enige voorbereiding vereist. Neem hiervoor dan ook de tijd wanneer de situatie dit toelaat, maak desnoods enkele aantekeningen. In een noodsituatie (bijvoorbeeld een luchtwegobstructie/reanimatiesetting) volstaat uiteraard naam en kamernummer/afdeling van de patiënt. Een verdere briefing kan aansluitend aan bed plaatsvinden terwijl ondertussen de levensreddende handelingen kunnen worden voortgezet.

Situation	Reason	<ul style="list-style-type: none"> ▪ Stel jezelf voor ▪ Controleer dat je met de juiste persoon spreekt ▪ Identificeer de patiënt (wie/waar) ▪ Benoem de reden van het gesprek: wat is de hulpvraag
Background	Story	<ul style="list-style-type: none"> ▪ Achtergrondinformatie omtrent de patiënt ▪ Reden van opname ▪ Relevante medische voorgeschiedenis
Assessment	Vital signs	<ul style="list-style-type: none"> ▪ Benoem de vitale functies (ABCDE + Early Warning Score) ▪ Benoem ook de trends en de effecten van eventuele interventies
Recommendation	Plan	<ul style="list-style-type: none"> ▪ Benoem conclusie ▪ Formuleer explicet de hulpvraag

Box 1. Voorbeeld SBAR/RSVP



Houd er rekening mee dat diegene die u aan de lijn krijgt andere prioriteiten kan hebben of wellicht nog niet goed wakker is. Deel, bij een complexe boodschap, de informatie op in korte zinnen en beperk u tot de relevante informatie. Door overbodige informatie te delen kan uw boodschap verloren gaan en krijgt u mogelijk niet de hulp die u nodig heeft. Controleer tot slot explicet of de boodschap is overgekomen en of de persoon aan de andere kant weet wat er van hem/haar wordt verwacht.

Miscommunicatie...

Communicatie hulpmiddelen:

- ✓ Closed loop
- ✓ Cross check
- ✓ Cross monitoring
- ✓ 10 for 10
- ✓ Roep bij naam
- ✓ Hardop denken
- ✓ samenvatten
- ✓ SPEAK UP.
- ✓ Structuur bijv RSVP / ABC (DE) / SBAR, MEWS, PEWS
- ✓ Checklists; Groen golf (time out en sign out).
- ✓ Reductie van ruis (stilte)
- ✓ Briefing/ Debriefing
- ✓ Escalatieladder
- ✓ Complimenten
- ✓ Feedback

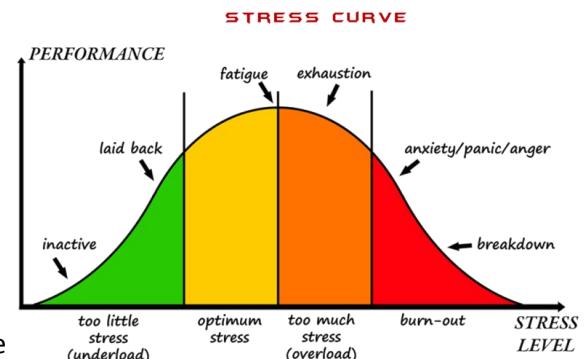
Opdracht 2:

Welke van deze hulpmiddelen kent U en gebruikt U ook? Wat is voor U het voordeel indien U (één van) deze hulpmiddelen toepast?



2.3 Stressmanagement

Hoewel we soms anders zouden willen, zijn wij hulpverleners ook maar mensen. Soms zijn er omstandigheden (die ook volledig los kunnen staan van ons werk) van invloed op hoe wij tijdens ons werk presteren. Denk bijvoorbeeld aan huwelijksproblemen, een pasgeboren baby die u de hele nacht wakker heeft gehouden, of veel simpeler die lunch die u vier uur geleden eigenlijk al had willen hebben of dat toiletbezoek wat u wegens drukte op de Spoedeisende Hulp maar uit blijft stellen. Ook weinig drukte kan nadelige effecten hebben op het alertheidsniveau (zie afbeelding stress curve).



Het lijkt een open deur, maar het is daarom niet minder waar: om goed voor een ander te kunnen zorgen zult u eerst goed voor uzelf moeten zorgen! Probeer open te zijn naar uw collega's over eventuele zaken die uw prestaties zouden kunnen beïnvloeden. Zij krijgen zo de kans om alert te zijn op mogelijke problemen en kunnen u waar nodig werk uit handen nemen. Geef bijvoorbeeld aan bij uw supervisor dat het uw eerste dienst is, u zult merken dat dit alleen al een deel van de stress weg kan nemen. In de luchtvaart is het heel normaal om hier actief naar te informeren, dit wordt "fit to fly" genoemd. Na de ramp met het toestel van German Wings in maart 2015 gaven verschillende piloten en leden van het cabine personeel aan zich "unfit to fly" te voelen door wat er was gebeurd. Daarop zijn zonder pardon verschillende vluchten afgelast. En terecht, of had u graag in een vliegtuig gezeten met een piloot die met zijn gedachten ergens anders was?

Voorbeeld van werkstress.... Waar in de curve zou deze werknemer zitten?

2.4 Groepsprocessen

Onder invloed van de mensen om ons heen zijn wij in staat dingen te doen die we normaliter niet zouden doen, of gedachten opzij te schuiven die anders in ons hoofd zouden blijven rondspoken. Ga maar bij uzelf na. U wordt bijvoorbeeld geroepen bij een zwangere vrouw met sectio in de voorgeschiedenis die nu wordt ingeleid bij 39 weken. U vertrouwt het niet en wilt informatie in bij de betreffende verpleegkundige en uw supervisor. Beiden hebben veel ervaring en zien geen reden tot zorg. Bovendien zijn de controles nu ook niet slecht, toch? Uw geweten wordt gesust...en later op de avond kunt u alsnog met de betreffende dame met spoed naar de OK ivm uterusruptuur..

Het fenomeen groepsdenken is al in verschillende experimenten gedemonstreerd, deze (wat gedateerde) video laat hier een fraai voorbeeld van zien:

[groepsdenken](#)

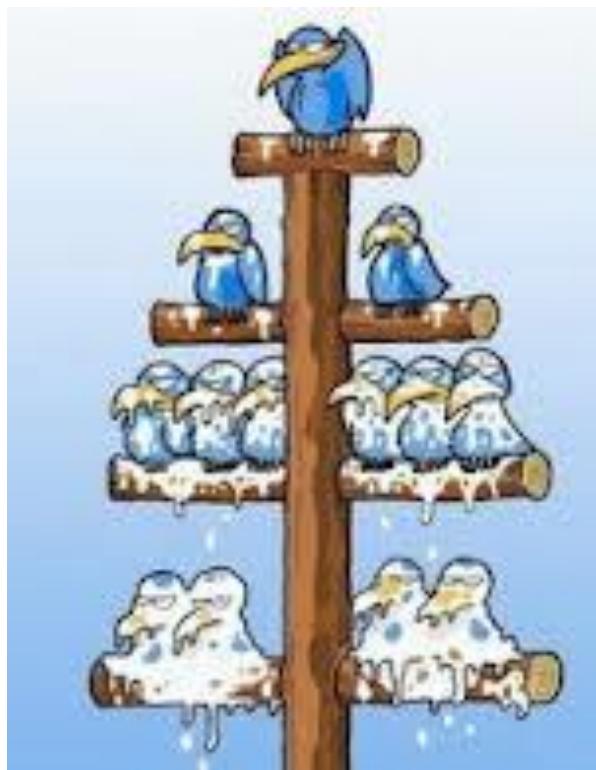
2.5 Leiderschap

Ieder team heeft een leider nodig. De leider houdt het overzicht, communiceert op heldere wijze met het team en verdeelt de werklast. Dit hoeft overigens niet altijd diegene te zijn die het hoogst in rang staat, ook al doet de titel dit wellicht wel vermoeden. De arts of verpleegkundige die het beste overzicht heeft over de actuele situatie kan deze taak vaak het beste op zich nemen. Een betere term was wellicht 'coördinator' geweest. Van groot belang is dat voor ieder teamlid te

allen tijde glashelder is wie de leiding heeft.

Even zo belangrijk als goed leiderschap is goed volgerschap. Een volger voert opdrachten zo goed mogelijk uit en denkt mee. De volger is in gelijke mate verantwoordelijk voor het welzijn van de patiënt. Zorgen/suggesties dienen dan ook met de leider te worden gedeeld. Wanneer problemen optreden in de samenwerking, dienen deze na afloop besproken te worden, zodat het team bij een eventuele volgende calamiteit weer optimaal kan functioneren.

Deze volgende animatie geeft op komische wijze het absolute belang van goed leider- en volgerschap weer: [leiderschap-en volgerschap](#)



Voorbeeld van hiërarchisch leiderschap. Deze leider “sees nothing but shit”, deze volgers “see nothing but assholes”....

Opdracht 3:

Welke eigenschappen vindt u belangrijk voor een goede leider? En welke voor een goede volger?

2.6 Besluitvorming

Besluitvorming dient te worden gezien in samenhang met leiderschap. De leider hakt, in overleg met het team, knopen door t.a.v. de behandeling. Een korte time out kan helpen om het benodigde overzicht te creëren. Door even kort stil te staan bij de situatie zoals die op dat moment bestaat en een duidelijk plan van aanpak te bespreken, komen alle teamleden weer op één lijn te zitten en verloopt de samenwerking zo optimaal mogelijk. Dit lijkt tijd te kosten, maar uiteindelijk betaalt het zich dubbel en dwars terug. Aan deze werkwijze rondom besluitvorming wordt gerefereerd als *Ten seconds for ten minutes*.

2.7 Risico-management

Door vooraf een situatie alvast te bespreken en de taken te verdelen, wordt direct vanaf het begin een zo goed mogelijke team situational awareness en samenwerking nastreefd. Dit is vooral zeer relevant wanneer er procedures moeten worden uitgevoerd. Door vooraf de procedure hardop door te nemen worden onaangename verrassingen tijdens de procedure voorkomen. Het is zeker ook zeer zinvol om situaties na te bespreken, en dan natuurlijk het liefst met alle betrokken hulpverleners. Dit geldt niet alleen voor calamiteiten, ook zaken die ogenschijnlijk vlekkeloos zijn verlopen kunnen prima worden nabesproken, want: "Wat maakte nu dat dit zo goed liep?"

In de bijlage bij dit hoofdstuk is een voorbeeld van een zakkaart zoals die in het Radboudumc op de neonatologie wordt gebruikt om de briefing en debriefing bij bijvoorbeeld de opvang van een neonaat > 32 weken te structureren.

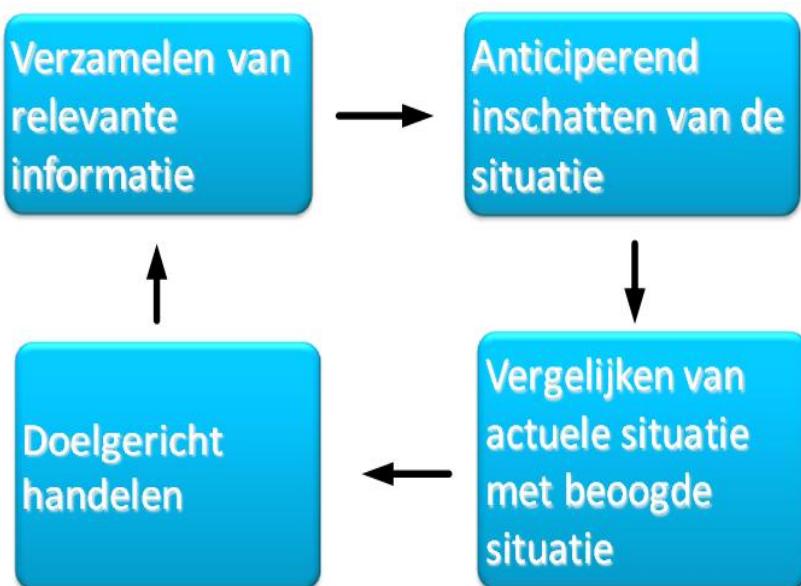


2.8 Situatie overzicht

Uw situatie overzicht is altijd een model of interpretatie van de werkelijkheid:

- Je kunt maar beperkte hoeveelheid informatie opnemen
- Geleidelijke veranderingen kun je over het hoofd zien
- Niet iedereen 'kijkt' op dezelfde manier
- Niet iedereen kan alles tegelijk waarnemen

Verder is van belang dat er sprake is van individueel situatie overzicht en team situatie overzicht.



Illustratief voorbeeld van hoe moeilijk situatie overzicht kan zijn:

[Situatie overzicht](#)

Opdracht 4:

Voor deze opdracht kunt u kiezen uit twee video's.

Video 1:

De eerste video is een video waarin, opnieuw met hulp van Martin Bromiley, een complicatie in een zorginstelling onder de loep wordt genomen. In een reconstructie, aangevuld met interviews met de betrokken patiënt, diens partner en de betrokken hulpverleners, wordt de situatie leidend tot de uiteindelijke complicatie geschatst. De video duurt ongeveer 23 minuten.

Met de 15 CRM-kernpunten in gedachten: probeer ter voorbereiding op de lesdag voorbeelden te verzamelen van de verschillende kernpunten zoals u deze in de video herkent.

Video 2:

Voor diegenen die inmiddels nieuwsgierig zijn geworden naar de toepassing van CRM in de luchtvaartindustrie is deze tweede video wellicht interessant. In deze video krijgt u een reconstructie te zien van een van de dodelijkste luchtvaartongelukken in de geschiedenis. Deze crash was het startpunt voor de ontwikkeling van CRM. De video duurt ongeveer 25 minuten. Hier geldt dezelfde opdracht. **Probeer ter voorbereiding op de lesdag voorbeelden te verzamelen van de verschillende kernpunten zoals u deze in de video herkent.**

Uiteraard staat het u vrij om beide video's te bekijken



Artikelen/checklist bij hoofdstuk 2

Lees onderstaande artikelen in de bijlage.

Let op: voor verpleegkundigen geldt voor de Engelse artikelen → alleen het artikel van **Rall&Diekman** is verplicht. De overige Engelse artikelen zijn voor verpleegkundigen optioneel.

- Checklist opvang neonaat > 32 weken Amalia kinderziekenhuis Radboudumc
- Artikel Burke&Priest:
How to turn a team of experts into an expert medical team: guidance from the aviation and military communities.
- Artikel Thomas&Galla:
Building a culture of safety through team training and engagement.
- Artikel Fransen&Oei:
Effect of obstetric team training on team performance and medical technical skills; a randomised controlled trial.



Bijlage

- Artikel: Wyllie&Urlesbergen:
**European Resuscitation Council Guidelines for resuscitation 2015 section 7.
Resuscitation and support of transition of babies at birth.**
- NLS algoritme 2016
- Artikel Rall&Diekman:
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(*=*optioneel voor verpleegkundigen*)





European Resuscitation Council Guidelines for Resuscitation 2015 Section 7. Resuscitation and support of transition of babies at birth



Jonathan Wyllie ^{a,*}, Jos Bruinenberg ^b, Charles Christoph Roehr ^{d,e}, Mario Rüdiger ^f,
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^d Department of Neonatology, Charité Universitätsmedizin, Berlin, Berlin, Germany

^e Newborn Services, John Radcliffe Hospital, Oxford University Hospitals, Oxford, UK

^f Department of Neonatology, Medizinische Fakultät Carl Gustav Carus, TU Dresden, Germany

^g Division of Neonatology, Medical University Graz, Graz, Austria

Introduction

The following guidelines for resuscitation at birth have been developed during the process that culminated in the 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR, 2015).^{1,2} They are an extension of the guidelines already published by the ERC³ and take into account recommendations made by other national and international organisations and previously evaluated evidence.⁴

Summary of changes since 2010 guidelines

The following are the main changes that have been made to the guidelines for resuscitation at birth in 2015:

- **Support of transition:** Recognising the unique situation of the baby at birth, who rarely requires 'resuscitation' but sometimes needs medical help during the process of postnatal transition. The term 'support of transition' has been introduced to better distinguish between interventions that are needed to restore vital organ functions (resuscitation) or to support transition.
- **Cord clamping:** For uncompromised babies, a delay in cord clamping of at least 1 min from the complete delivery of the infant, is now recommended for term and preterm babies. As yet there is insufficient evidence to recommend an appropriate time for clamping the cord in babies who require resuscitation at birth.
- **Temperature:** The temperature of newly born non-asphyxiated infants should be maintained between 36.5 °C and 37.5 °C after birth. The importance of achieving this has been highlighted and

reinforced because of the strong association with mortality and morbidity. The admission temperature should be recorded as a predictor of outcomes as well as a quality indicator.

- **Maintenance of temperature:** At <32 weeks gestation, a combination of interventions may be required to maintain the temperature between 36.5 °C and 37.5 °C after delivery through admission and stabilisation. These may include warmed humidified respiratory gases, increased room temperature plus plastic wrapping of body and head, plus thermal mattress or a thermal mattress alone, all of which have been effective in reducing hypothermia.
- **Optimal assessment of heart rate:** It is suggested in babies requiring resuscitation that the ECG can be used to provide a rapid and accurate estimation of heart rate.
- **Meconium:** Tracheal intubation should not be routine in the presence of meconium and should only be performed for suspected tracheal obstruction. The emphasis should be on initiating ventilation within the first minute of life in non-breathing or ineffectively breathing infants and this should not be delayed.
- **Air/Oxygen:** Ventilatory support of term infants should start with air. For preterm infants, either air or a low concentration of oxygen (up to 30%) should be used initially. If, despite effective ventilation, oxygenation (ideally guided by oximetry) remains unacceptable, use of a higher concentration of oxygen should be considered.
- **Continuous Positive Airways Pressure (CPAP):** Initial respiratory support of spontaneously breathing preterm infants with respiratory distress may be provided by CPAP rather than intubation.

The guidelines that follow do not define the only way that resuscitation at birth should be achieved; they merely represent a widely accepted view of how resuscitation at birth can be carried out both safely and effectively (Fig. 7.1).

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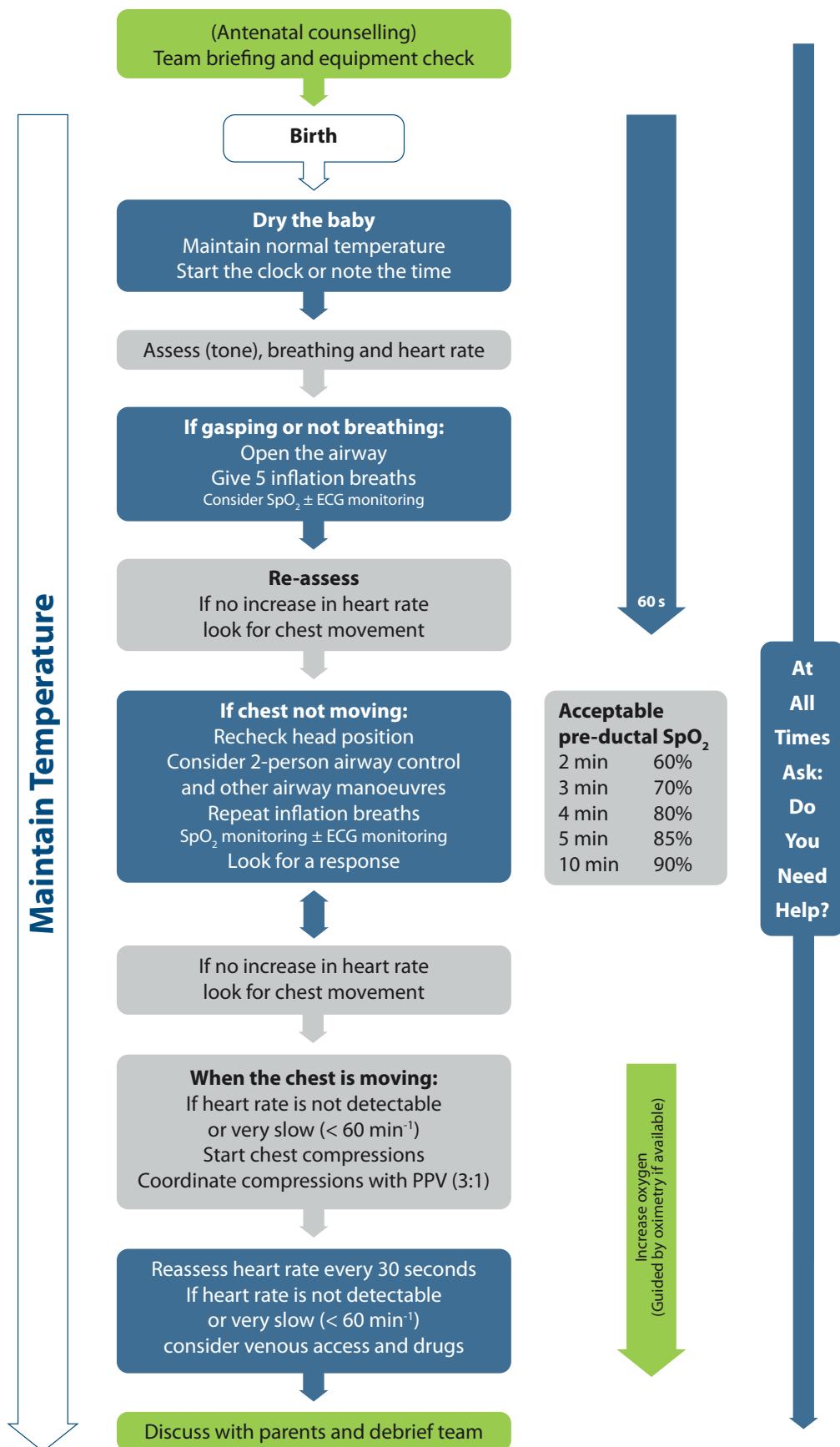


Fig. 7.1. Newborn life support algorithm. SpO_2 : transcutaneous pulse oximetry, ECG: electrocardiograph, PPV: positive pressure ventilation.

Preparation

The fetal-to-neonatal transition, which occurs at the time of birth, requires anatomic and physiological adjustments to achieve the conversion from placental gas exchange with intra-uterine lungs filled with fluid, to pulmonary respiration with aerated lungs. The absorption of lung fluid, the aeration of the lungs, the initiation of air breathing, and cessation of the placental circulation bring about this transition.

A minority of infants require resuscitation at birth, but a few more have problems with this perinatal transition, which, if no support is given, might subsequently result in a need for resuscitation. Of those needing any help, the overwhelming majority will require only assisted lung aeration. A tiny minority may need a brief period of chest compressions in addition to lung aeration. In a retrospective study, approximately 85% of babies born at term initiated spontaneous respirations within 10 to 30 s of birth; an additional 10% responded during drying and stimulation, approximately 3% initiated respirations following positive pressure ventilation, 2% were intubated to support respiratory function and 0.1% received chest compressions and/or adrenaline.^{5–7} However, of 97,648 babies born in Sweden in one year, only 10 per 1000 (1%) babies of 2.5 kg or more appeared to need any resuscitation at delivery.⁸ Most of those, 8 per 1000, responded to mask inflation of the lungs and only 2 per 1000 appeared to need intubation. The same study tried to assess the unexpected need for resuscitation at birth and found that for low risk babies, i.e. those born after 32 weeks gestation and following an apparently normal labour, about 2 per 1000 (0.2%) appeared to need resuscitation or help with transition at delivery. Of these, 90% responded to mask ventilation alone while the remaining 10% appeared not to respond to mask inflation and therefore were intubated at birth. There was almost no need for cardiac compressions.

Resuscitation or support of transition is more likely to be needed by babies with intrapartum evidence of significant fetal compromise, babies delivering before 35 weeks gestation, babies delivering vaginally by the breech, maternal infection and multiple pregnancies.⁹ Furthermore, caesarean delivery is associated with an increased risk of problems with respiratory transition at birth requiring medical interventions especially for deliveries before 39 weeks gestation.^{10–13} However, elective caesarean delivery at term does not increase the risk of needing newborn resuscitation in the absence of other risk factors.^{14–17}

Although it is sometimes possible to predict the need for resuscitation or stabilisation before a baby is born, this is not always the case. Any newborn may potentially develop problems during birth, therefore, personnel trained in newborn life support should be easily available for every delivery. In deliveries with a known increased risk of problems, specially trained personnel should be present with at least one person experienced in tracheal intubation. Should there be any need for intervention, the care of the baby should be their sole responsibility. Local guidelines indicating who should attend deliveries should be developed, based on current practice and clinical audit. Each institution should have a protocol in place for rapidly mobilising a team with competent resuscitation skills for any birth. Whenever there is sufficient time, the team attending the delivery should be briefed before delivery and clear role assignment should be defined. It is also important to prepare the family in cases where it is likely that resuscitation might be required.

A structured educational programme, teaching the standards and skills required for resuscitation of the newborn is therefore essential for any institution or clinical area in which deliveries may occur. Continued experiential learning and practice is necessary to maintain skills.

Planned home deliveries

Recommendations as to who should attend a planned home delivery vary from country to country, but the decision to undergo a planned home delivery, once agreed with medical and midwifery staff, should not compromise the standard of initial assessment, stabilisation or resuscitation at birth. There will inevitably be some limitations to resuscitation of a newborn baby in the home, because of the distance from further assistance, and this must be made clear to the mother at the time plans for home delivery are made. Ideally, two trained professionals should be present at all home deliveries; one of these must be fully trained and experienced in providing mask ventilation and chest compressions in the newborn.

Equipment and environment

Unlike adult cardiopulmonary resuscitation (CPR), resuscitation at birth is often a predictable event. It is therefore possible to prepare the environment and the equipment before delivery of the baby. Resuscitation should take place in a warm, well-lit, draught free area with a flat resuscitation surface placed below a radiant heater (if in hospital), with other resuscitation equipment immediately available. All equipment must be regularly checked and tested.

When a birth takes place in a non-designated delivery area, the recommended minimum set of equipment includes a device for safe assisted lung aeration and subsequent ventilation of an appropriate size for the newborn, warm dry towels and blankets, a sterile instrument for cutting and clamping the umbilical cord and clean gloves for the attendant and assistants. Unexpected deliveries outside hospital are most likely to involve emergency services that should plan for such events.

Timing of clamping the umbilical cord

Cine-radiographic studies of babies taking their first breath at delivery showed that those whose cords were clamped prior to this had an immediate decrease in the size of the heart during the subsequent three or four cardiac cycles. The heart then increased in size to almost the same size as the fetal heart. The initial decrease in size could be interpreted as the significantly increased pulmonary blood flow following the decrease in pulmonary vascular resistance upon lung aeration. The subsequent increase in size would, as a consequence, be caused by the blood returning to the heart from the lung.¹⁸ Brady et al drew attention to the occurrence of a bradycardia apparently induced by clamping the cord before the first breath and noted that this did not occur in babies where clamping occurred after breathing was established.¹⁹ Experimental evidence from similarly treated lambs suggest the same holds true for premature newborn.²⁰

Studies of delayed clamping have shown an improvement in iron status and a number of other haematological indices over the next 3–6 months and a reduced need for transfusion in preterm infants.^{21,22} They have also suggested greater use of phototherapy for jaundice in the delayed group but this was not found in a randomised controlled trial.²¹

A systematic review on delayed cord clamping and cord milking in preterm infants found improved stability in the immediate postnatal period, including higher mean blood pressure and haemoglobin on admission, compared to controls.²³ There were also fewer blood transfusions in the ensuing weeks.²³ Some studies have suggested a reduced incidence of intraventricular haemorrhage and periventricular leukomalacia^{22,24,25} as well as of late-onset sepsis.²⁴

No human studies have yet addressed the effect of delaying cord clamping on babies apparently needing resuscitation at birth because such babies have been excluded from previous studies.

Delaying umbilical cord clamping for at least 1 min is recommended for newborn infants not requiring resuscitation. A similar delay should be applied to preterm babies not requiring immediate resuscitation after birth. Until more evidence is available, infants who are not breathing or crying may require the umbilical cord to be clamped, so that resuscitation measures can commence promptly. Umbilical cord milking may prove an alternative in these infants although there is currently not enough evidence available to recommend this as a routine measure.^{1,2} Umbilical cord milking produces improved short term haematological outcomes, admission temperature and urine output when compared to delayed cord clamping (>30 s) in babies born by caesarean section, although these differences were not observed in infants born vaginally.²⁶

Temperature control

Naked, wet, newborn babies cannot maintain their body temperature in a room that feels comfortably warm for adults. Compromised babies are particularly vulnerable.²⁷ Exposure of the newborn to cold stress will lower arterial oxygen tension²⁸ and increase metabolic acidosis.²⁹ The association between hypothermia and mortality has been known for more than a century,³⁰ and the admission temperature of newborn non-asphyxiated infants is a strong predictor of mortality at all gestations and in all settings.^{31–65} Preterm infants are especially vulnerable and hypothermia is also associated with serious morbidities such as intraventricular haemorrhage^{35,42,55,66–69} need for respiratory support^{31,35,37,66,70–74} hypoglycaemia^{31,49,60,74–79} and in some studies late onset sepsis.⁴⁹

The temperature of newly born non-asphyxiated infants should be maintained between 36.5 °C and 37.5 °C after birth. For each 1 °C decrease in admission temperature below this range there is an associated increase in mortality by 28%.^{1,2,49} The admission temperature should be recorded as a predictor of outcomes as well as a quality indicator.

Prevent heat loss:

- Protect the baby from draughts.⁸⁰ Make certain windows closed and air-conditioning appropriately programmed.⁵²
- Dry the term baby immediately after delivery. Cover the head and body of the baby, apart from the face, with a warm and dry towel to prevent further heat loss. Alternatively, place the baby skin to skin with mother and cover both with a towel.
- Keep the delivery room warm at 23–25 °C.^{1,2,48,80} For babies less than 28 weeks gestation the delivery room temperature should be >25 °C.^{27,48,79,81}
- If the baby needs support in transition or resuscitation then place the baby on a warm surface under a preheated radiant warmer.
- All babies less than 32 weeks gestation should have the head and body of the baby (apart from the face) covered with polyethylene wrapping, without drying the baby beforehand, and also placed under a radiant heater.^{73,77,82,83}
- In addition, babies <32 weeks gestation, may require a combination of further interventions to maintain the temperature between 36.5 °C and 37.5 °C after delivery through admission and stabilisation. These may include warmed humidified respiratory gases,^{84,85} increased room temperature plus cap plus thermal mattress^{70,72,86,87} or thermal mattress alone,^{88–92} which have all been effective in reducing hypothermia.
- Babies born unexpectedly outside a normal delivery environment may benefit from placement in a food grade plastic bag after drying and then swaddling.^{93,94} Alternatively, well newborns >30

weeks gestation may be dried and nursed with skin to skin contact or kangaroo mother care to maintain their temperature whilst they are transferred.^{95–101} They should be covered and protected from draughts.

Whilst maintenance of a baby's temperature is important, this should be monitored in order to avoid hyperthermia (>38.0 °C). Infants born to febrile mothers have a higher incidence of perinatal respiratory depression, neonatal seizures, early mortality and cerebral palsy.^{102,103} Animal studies indicate that hyperthermia during or following ischaemia is associated with a progression of cerebral injury.^{104,105}

Initial assessment

The Apgar score was not designed to be assembled and ascribed in order to then identify babies in need of resuscitation.^{106,107} However, individual components of the score, namely respiratory rate, heart rate and tone, if assessed rapidly, can identify babies needing resuscitation, (and Virginia Apgar herself found that heart rate was the most important predictor of immediate outcome).¹⁰⁶ Furthermore, repeated assessment particularly of heart rate and, to a lesser extent breathing, can indicate whether the baby is responding or whether further efforts are needed.

Breathing

Check whether the baby is breathing. If so, evaluate the rate, depth and symmetry of breathing together with any evidence of an abnormal breathing pattern such as gasping or grunting.

Heart rate

Immediately after birth the heart rate is assessed to evaluate the condition of the baby and subsequently is the most sensitive indicator of a successful response to interventions. Heart rate is initially most rapidly and accurately assessed by listening to the apex beat with a stethoscope¹⁰⁸ or by using an electrocardiograph.^{109–112} Feeling the pulse in the base of the umbilical cord is often effective but can be misleading because cord pulsation is only reliable if found to be more than 100 beats per minute (bpm)¹⁰⁸ and clinical assessment may underestimate the heart rate.^{108,109,113} For babies requiring resuscitation and/or continued respiratory support, a modern pulse oximeter can give an accurate heart rate.¹¹¹ Several studies have demonstrated that ECG is faster than pulse oximetry and more reliable, especially in the first 2 min after birth;^{110–115} however, the use of ECG does not replace the need to use pulse oximetry to assess the newborn baby's oxygenation.

Colour

Colour is a poor means of judging oxygenation,¹¹⁶ which is better assessed using pulse oximetry if possible. A healthy baby is born blue but starts to become pink within 30 s of the onset of effective breathing. Peripheral cyanosis is common and does not, by itself, indicate hypoxaemia. Persistent pallor despite ventilation may indicate significant acidosis or rarely hypovolaemia. Although colour is a poor method of judging oxygenation, it should not be ignored: if a baby appears blue, check preductal oxygenation with a pulse oximeter.

Tone

A very floppy baby is likely to be unconscious and will need ventilatory support.

Tactile stimulation

Drying the baby usually produces enough stimulation to induce effective breathing. Avoid more vigorous methods of stimulation. If the baby fails to establish spontaneous and effective breaths following a brief period of stimulation, further support will be required.

Classification according to initial assessment

On the basis of the initial assessment, the baby can be placed into one of three groups:

(1)	Vigorous breathing or crying. Good tone. Heart rate higher than 100 min^{-1} .
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There is no need for immediate clamping of the cord. This baby requires no intervention other than drying, wrapping in a warm towel and, where appropriate, handing to the mother. The baby will remain warm through skin-to-skin contact with mother under a cover, and may be put to the breast at this stage. It remains important to ensure the baby's temperature is maintained.

(2)	Breathing inadequately or apnoeic. Normal or reduced tone. Heart rate less than 100 min^{-1} .
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Dry and wrap. This baby will usually improve with mask inflation but if this does not increase the heart rate adequately, may rarely also require ventilations.

(3)	Breathing inadequately or apnoeic. Floppy. Low or undetectable heart rate. Often pale suggesting poor perfusion.
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Dry and wrap. This baby will then require immediate airway control, lung inflation and ventilation. Once this has been successfully accomplished the baby may also need chest compressions, and perhaps drugs.

Preterm babies may be breathing and showing signs of respiratory distress in which case they should be supported initially with CPAP.

There remains a very rare group of babies who, though breathing with a good heart rate, remain hypoxaemic. This group includes a range of possible diagnoses such as cyanotic congenital heart disease, congenital pneumonia, pneumothorax, diaphragmatic hernia or surfactant deficiency.

Newborn life support

Commence newborn life support if initial assessment shows that the baby has failed to establish adequate regular normal breathing, or has a heart rate of less than 100 min^{-1} (Fig. 7.1). Opening the airway and aerating the lungs is usually all that is necessary. Furthermore, more complex interventions will be futile unless these two first steps have been successfully completed.

Airway

Place the baby on his or her back with the head in a neutral position (Fig. 7.2). A 2 cm thickness of the blanket or towel placed under the baby's shoulder may be helpful in maintaining proper head position. In floppy babies application of jaw thrust or the use of an appropriately sized oropharyngeal airway may be essential in opening the airway.

The supine position for airway management is traditional but side-lying has also been used for assessment and routine delivery room management of term newborns but not for resuscitation.¹¹⁷



Fig. 7.2. Newborn with head in neutral position.

There is no need to remove lung fluid from the oropharynx routinely.¹¹⁸ Suction is needed only if the airway is obstructed. Obstruction may be caused by particulate meconium but can also be caused by blood clots, thick tenacious mucus or vernix even in deliveries where meconium staining is not present. However, aggressive pharyngeal suction can delay the onset of spontaneous breathing and cause laryngeal spasm and vagal bradycardia.^{119–121}

Meconium

For over 30 years it was hoped that clearing meconium from the airway of babies at birth would reduce the incidence and severity of meconium aspiration syndrome (MAS). However, studies supporting this view were based on a comparison of suctioning on the outcome of a group of babies with the outcome of historical controls.^{122,123} Furthermore other studies failed to find any evidence of benefit from this practice.^{124,125}

Lightly meconium stained liquor is common and does not, in general, give rise to much difficulty with transition. The much less common finding of very thick meconium stained liquor at birth is an indicator of perinatal distress and should alert to the potential need for resuscitation. Two multi-centre randomised controlled trials showed that routine elective intubation and tracheal suctioning of these infants, if vigorous at birth, did not reduce MAS¹²⁶ and that suctioning the nose and mouth of such babies on the perineum and before delivery of the shoulders (intrapartum suctioning) was ineffective.¹²⁷ Hence intrapartum suctioning and routine intubation and suctioning of vigorous infants born through meconium stained liquor are not recommended. A small RCT has recently demonstrated no difference in the incidence of MAS between patients receiving tracheal intubation followed by suctioning and those not intubated.¹²⁸

The presence of thick, viscous meconium in a non-vigorous baby is the only indication for initially considering visualising the oropharynx and suctioning material, which might obstruct the airway. Tracheal intubation should not be routine in the presence of meconium and should only be performed for suspected tracheal obstruction.^{128–132} The emphasis should be on initiating ventilation within the first minute of life in non-breathing or ineffectively breathing infants and this should not be delayed. If suctioning is attempted use a 12–14 FG suction catheter, or a paediatric Yankauer sucker, connected to a suction source not exceeding -150 mmHg .¹³³ The routine administration of surfactant or bronchial lavage with either saline or surfactant is not recommended.^{134,135}

Initial breaths and assisted ventilation

After initial steps at birth, if breathing efforts are absent or inadequate, lung aeration is the priority and must not be delayed (Fig. 7.3). In term babies, respiratory support should start with air.¹³⁶ The primary measure of adequate initial lung inflation is a



Fig. 7.3. Mask ventilation of newborn.

prompt improvement in heart rate. If the heart rate is not improving assess the chest wall movement. In term infants, spontaneous or assisted initial inflations create a functional residual capacity (FRC).^{137–141} The optimum pressure, inflation time and flow required to establish an effective FRC has not been determined.

For the first five positive pressure inflations maintain the initial inflation pressure for 2–3 s. This will usually help lung expansion.^{137,142} The pressure required to aerate the fluid filled lungs of newborn babies requiring resuscitation is 15–30 cm H₂O (1.5–2.9 kPa) with a mean of 20 cm H₂O.^{137,141,142} For term babies use an inflation pressure of 30 cm H₂O and 20–25 cm H₂O in preterm babies.^{143,144}

Efficacy of the intervention can be estimated by a prompt increase in heart rate or observing the chest rise. If this is not obtained it is likely that repositioning of the airway or mask will be required and, rarely, higher inspiratory pressures may be needed. Most babies needing respiratory support at birth will respond with a rapid increase in heart rate within 30 s of lung inflation. If the heart rate increases but the baby is not breathing adequately, ventilate at a rate of about 30 breaths min⁻¹ allowing approximately 1 s for each inflation, until there is adequate spontaneous breathing.

Adequate passive ventilation is usually indicated by either a rapidly increasing heart rate or a heart rate that is maintained faster than 100 beats min⁻¹. If the baby does not respond in this way the most likely cause is inadequate airway control or inadequate ventilation. Look for passive chest movement in time with inflation efforts; if these are present then lung aeration has been achieved. If these are absent then airway control and lung aeration has not been confirmed. Mask leak, inappropriate airway position and airway obstruction, are all possible reasons, which may need correction.^{145–149} In this case, consider repositioning the mask to correct for leakage and/or reposition the baby's head to correct for airway obstruction.¹⁴⁵ Alternatively using a two person approach to mask ventilation reduces mask leak in term and preterm infants.^{146,147} Without adequate lung aeration, chest compressions will be ineffective; therefore, confirm lung aeration and ventilation before progressing to circulatory support.

Some practitioners will ensure airway control by tracheal intubation, but this requires training and experience. If this skill is not available and the heart rate is decreasing, re-evaluate the airway position and deliver inflation breaths while summoning a colleague with intubation skills. Continue ventilatory support until the baby has established normal regular breathing.

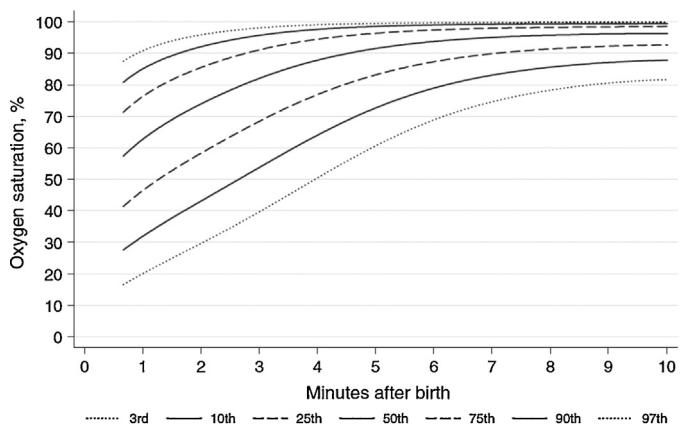


Fig. 7.4. Oxygen saturations (3rd, 10th, 25th, 50th, 75th, 90th and 97th SpO₂ percentiles) in healthy infants at birth without medical intervention. Reproduced with permission from.¹⁵⁷

Sustained inflations (SI)>5 s

Several animal studies have suggested that a longer SI may be beneficial for establishing functional residual capacity at birth during transition from a fluid-filled to air-filled lung.^{150,151} Review of the literature in 2015 disclosed three RCTs^{152–154} and two cohort studies,^{144,155} which demonstrated that initial SI reduced the need for mechanical ventilation. However, no benefit was found for reduction of mortality, bronchopulmonary dysplasia, or air leak. One cohort study¹⁴⁴ suggested that the need for intubation was less following SI. It was the consensus of the COSTR reviewers that there was inadequate study of the safety, details of the most appropriate length and pressure of inflation, and long-term effects, to suggest routine application of SI of greater than 5 s duration to the transitioning newborn.^{1,2} Sustained inflations >5 s should only be considered in individual clinical circumstances or in a research setting.

Air/Oxygen

Term babies. In term infants receiving respiratory support at birth with positive pressure ventilation (PPV), it is best to begin with air (21%) as opposed to 100% oxygen. If, despite effective ventilation, there is no increase in heart rate or oxygenation (guided by oximetry wherever possible) remains unacceptable, use a higher concentration of oxygen to achieve an adequate preductal oxygen saturation.^{156,157} High concentrations of oxygen are associated with an increased mortality and delay in time of onset of spontaneous breathing,¹⁵⁸ therefore, if increased oxygen concentrations are used they should be weaned as soon as possible.^{136,159}

Preterm babies. Resuscitation of preterm infants less than 35 weeks gestation at birth should be initiated in air or low concentration oxygen (21–30%).^{1,2,136,160} The administered oxygen concentration should be titrated to achieve acceptable pre-ductal oxygen saturations approximating to the 25th percentile in healthy term babies immediately after birth (Fig. 7.4).^{156,157}

In a meta-analysis of seven randomized trials comparing initiation of resuscitation with high (>65%) or low (21–30%) oxygen concentrations, the high concentration was not associated with any improvement in survival,^{159,161–166} bronchopulmonary dysplasia,^{159,162,164–166} intraventricular haemorrhage^{159,162,165,166} or retinopathy of prematurity.^{159,162,166} There was an increase in markers of oxidative stress.¹⁵⁹

Pulse oximetry. Modern pulse oximetry, using neonatal probes, provides reliable readings of heart rate and transcutaneous oxygen saturation within 1–2 min of birth (Fig. 7.4).^{167,168} A reliable

pre-ductal reading can be obtained from >90% of normal term births, approximately 80% of those born preterm, and 80–90% of those apparently requiring resuscitation, within 2 min of birth.¹⁶⁷ Uncompromised babies born at term at sea level have SpO₂ ~60% during labour,¹⁶⁹ which increases to >90% by 10 min.¹⁵⁶ The 25th percentile is approximately 40% at birth and increases to ~80% at 10 min.¹⁵⁷ Values are lower in those born by Caesarean delivery,¹⁷⁰ those born at altitude¹⁷¹ and those managed with delayed cord clamping.¹⁷² Those born preterm may take longer to reach >90%.¹⁵⁷

Pulse oximetry should be used to avoid excessive use of oxygen as well as to direct its judicious use (Figs. 7.1 and 7.4). Transcutaneous oxygen saturations above the acceptable levels should prompt weaning of any supplemental oxygen.

Positive end expiratory pressure

All term and preterm babies who remain apnoeic despite initial steps must receive positive pressure ventilation after initial lung inflation. It is suggested that positive end expiratory pressure (PEEP) of ~5 cm H₂O should be administered to preterm newborn babies receiving PPV.¹⁷³

Animal studies show that preterm lungs are easily damaged by large-volume inflations immediately after birth¹⁷⁴ and suggest that maintaining a PEEP immediately after birth may protect against lung damage^{175,176} although some evidence suggests no benefit.¹⁷⁷ PEEP also improves lung aeration, compliance and gas exchange.^{178–180} Two human newborn RCTs demonstrated no improvement in mortality, need for resuscitation or bronchopulmonary dysplasia they were underpowered for these outcomes.^{181,182} However, one of the trials suggested that PEEP reduced the amount of supplementary oxygen required.¹⁸²

Assisted ventilation devices

Effective ventilation can be achieved with a flow-inflating, a self-inflating bag or with a T-piece mechanical device designed to regulate pressure.^{181–185} The blow-off valves of self-inflating bags are flow-dependent and pressures generated may exceed the value specified by the manufacturer if compressed vigorously.^{186,187} Target inflation pressures, tidal volumes and long inspiratory times are achieved more consistently in mechanical models when using T-piece devices than when using bags,^{187–190} although the clinical implications are not clear. More training is required to provide an appropriate pressure using flow-inflating bags compared with self-inflating bags.¹⁹¹ A self-inflating bag, a flow-inflating bag or a T-piece mechanical device, all designed to regulate pressure or limit pressure applied to the airway can be used to ventilate a newborn. However, self-inflating bags are the only devices, which can be used in the absence of compressed gas but cannot deliver continuous positive airway pressure (CPAP) and may not be able to achieve PEEP even with a PEEP valve in place.^{189,192–195}

Respiratory function monitors measuring inspiratory pressures and tidal volumes¹⁹⁶ and exhaled carbon dioxide monitors to assess ventilation^{197,198} have been used but there is no evidence that they affect outcomes. Neither additional benefit above clinical assessment alone, nor risks attributed to their use have so far been identified. The use of exhaled CO₂ detectors to assess ventilation with other interfaces (e.g., nasal airways, laryngeal masks) during PPV in the delivery room has not been reported.

Face mask versus nasal prong

A reported problem of using the facemask for newborn ventilation is mask leak caused by a failure of the seal between the mask and the face.^{145–148} To avoid this some institutions are using nasopharyngeal prongs to deliver respiratory support. Two randomised

Table 1
Oral tracheal tube lengths by gestation.

Gestation (weeks)	ETT at lips (cm)
23–24	5.5
25–26	6.0
27–29	6.5
30–32	7.0
33–34	7.5
35–37	8.0
38–40	8.5
41–43	9.0

trials in preterm infants have compared the efficacy and did not find any difference between the methods.^{199,200}

Laryngeal mask airway

The laryngeal mask airway can be used in resuscitation of the newborn, particularly if facemask ventilation is unsuccessful or tracheal intubation is unsuccessful or not feasible. The LMA may be considered as an alternative to a facemask for positive pressure ventilation among newborns weighing more than 2000 g or delivered ≥34 weeks gestation.²⁰¹ One recent unblinded RCT demonstrated that following training with one type of LMA, its use was associated with less tracheal intubation and neonatal unit admission in comparison to those receiving ventilation via a facemask.²⁰¹ There is limited evidence, however, to evaluate its use for newborns weighing <2000 gram or delivered <34 weeks gestation. The laryngeal mask airway may be considered as an alternative to tracheal intubation as a secondary airway for resuscitation among newborns weighing more than 2000 g or delivered ≥34 weeks gestation.^{201–206} The LMA is recommended during resuscitation of term and preterm newborns ≥34 weeks gestation when tracheal intubation is unsuccessful or not feasible. The laryngeal mask airway has not been evaluated in the setting of meconium stained fluid, during chest compressions, or for the administration of emergency intra-tracheal medications.

Tracheal tube placement

Tracheal intubation may be considered at several points during neonatal resuscitation:

- When suctioning the lower airways to remove a presumed tracheal blockage.
- When, after correction of mask technique and/or the baby's head position, bag-mask ventilation is ineffective or prolonged.
- When chest compressions are performed.
- Special circumstances (e.g., congenital diaphragmatic hernia or to give tracheal surfactant).

The use and timing of tracheal intubation will depend on the skill and experience of the available resuscitators. Appropriate tube lengths based on gestation are shown in Table 1.²⁰⁷ It should be recognised that vocal cord guides, as marked on tracheal tubes by different manufacturers to aid correct placement, vary considerably.²⁰⁸

Tracheal tube placement must be assessed visually during intubation, and positioning confirmed. Following tracheal intubation and intermittent positive-pressure, a prompt increase in heart rate is a good indication that the tube is in the tracheobronchial tree.²⁰⁹ Exhaled CO₂ detection is effective for confirmation of tracheal tube placement in infants, including VLBW infants^{210–213} and neonatal studies suggest that it confirms tracheal intubation in neonates with a cardiac output more rapidly and more accurately than clinical assessment alone.^{212–214} Failure to detect exhaled CO₂ strongly suggests oesophageal intubation^{210,212} but false negative readings have been reported during cardiac arrest²¹⁰ and in VLBW infants

despite models suggesting efficacy.²¹⁵ However, neonatal studies have excluded infants in need of extensive resuscitation. False positives may occur with colorimetric devices contaminated with adrenaline (epinephrine), surfactant and atropine.¹⁹⁸

Poor or absent pulmonary blood flow or tracheal obstruction may prevent detection of exhaled CO₂ despite correct tracheal tube placement. Tracheal tube placement is identified correctly in nearly all patients who are not in cardiac arrest²¹¹; however, in critically ill infants with poor cardiac output, inability to detect exhaled CO₂ despite correct placement may lead to unnecessary extubation. Other clinical indicators of correct tracheal tube placement include evaluation of condensed humidified gas during exhalation and presence or absence of chest movement, but these have not been evaluated systematically in newborn babies.

Detection of exhaled carbon dioxide in addition to clinical assessment is recommended as the most reliable method to confirm tracheal placement in neonates with spontaneous circulation.^{3,4}

CPAP

Initial respiratory support of all spontaneously breathing preterm infants with respiratory distress may be provided by CPAP, rather than intubation. Three RCTs enrolling 2358 infants born at <30 weeks gestation demonstrated that CPAP is beneficial when compared to initial tracheal ventilation and PPV in reducing the rate of intubation and duration of mechanical ventilation without any short term disadvantages.^{216–218} There are few data to guide the appropriate use of CPAP in term infants at birth and further clinical studies are required.^{219,220}

Circulatory support

Circulatory support with chest compressions is effective only if the lungs have first been successfully inflated. Give chest compressions if the heart rate is less than 60 beats min⁻¹ despite adequate ventilation. As ventilation is the most effective and important intervention in newborn resuscitation, and may be compromised by compressions, it is vital to ensure that effective ventilation is occurring before commencing chest compressions.

The most effective technique for providing chest compressions is with two thumbs over the lower third of the sternum with the fingers encircling the torso and supporting the back (Fig. 7.5).^{221–224} This technique generates higher blood pressures and coronary artery perfusion with less fatigue than the previously used two-finger technique.^{222–234} In a manikin study overlapping the thumbs on the sternum was more effective than positioning them adjacent but more likely to cause fatigue.²³⁵ The sternum is compressed to a depth of approximately one-third of the anterior-posterior diameter of the chest allowing the chest wall to return to its relaxed position between compressions.^{225,236–240} Use a 3:1 compression to ventilation ratio, aiming to achieve approximately 120 events per minute, i.e. approximately 90 compressions and 30 ventilations.^{241–246} There are theoretical advantages to allowing a relaxation phase that is very slightly longer than the compression phase.²⁴⁷ However, the quality of the compressions and breaths are probably more important than the rate. Compressions and ventilations should be coordinated to avoid simultaneous delivery.²⁴⁸ A 3:1 compression to ventilation ratio is used for resuscitation at birth where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse, but rescuers may consider using higher ratios (e.g., 15:2) if the arrest is believed to be of cardiac origin.

When resuscitation of a newborn baby has reached the stage of chest compressions, the steps of trying to achieve return of spontaneous circulation using effective ventilation with low

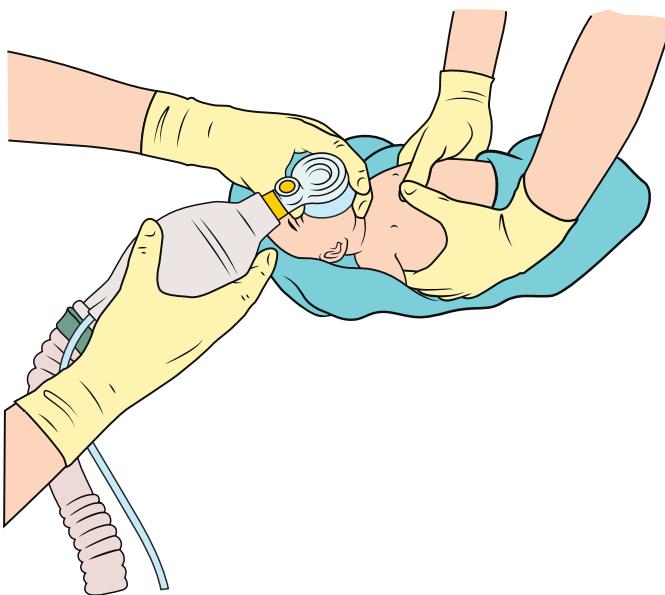


Fig. 7.5. Ventilation and chest compression of newborn.

concentration oxygen should have been attempted. Thus, it would appear sensible to try increasing the supplementary oxygen concentration towards 100%. There are no human studies to support this and animal studies demonstrate no advantage to 100% oxygen during CPR.^{249–255}

Check the heart rate after about 30 s and periodically thereafter. Discontinue chest compressions when the spontaneous heart rate is faster than 60 beats min⁻¹. Exhaled carbon dioxide monitoring and pulse oximetry have been reported to be useful in determining the return of spontaneous circulation^{256–260}; however, current evidence does not support the use of any single feedback device in a clinical setting.^{1,2}

Drugs

Drugs are rarely indicated in resuscitation of the newly born infant. Bradycardia in the newborn infant is usually caused by inadequate lung inflation or profound hypoxia, and establishing adequate ventilation is the most important step to correct it. However, if the heart rate remains less than 60 beats min⁻¹ despite adequate ventilation and chest compressions, it is reasonable to consider the use of drugs. These are best given via a centrally positioned umbilical venous catheter (Fig. 7.6).

Adrenaline

Despite the lack of human data it is reasonable to use adrenaline when adequate ventilation and chest compressions have failed to increase the heart rate above 60 beats min⁻¹. If

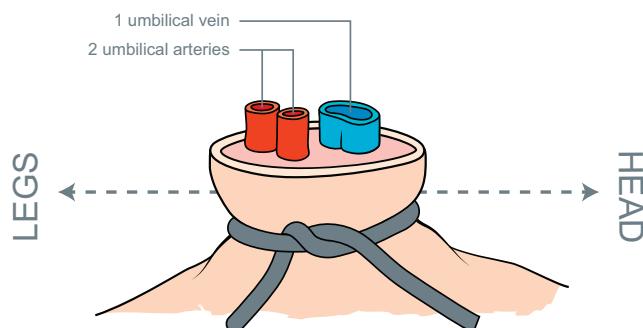


Fig. 7.6. Newborn umbilical cord showing the arteries and veins.

adrenaline is used, an initial dose 10 micrograms kg⁻¹ (0.1 ml kg⁻¹ of 1:10,000 adrenaline) should be administered intravenously as soon as possible^{1,2,4} with subsequent intravenous doses of 10–30 micrograms kg⁻¹ (0.1–0.3 ml kg⁻¹ of 1:10,000 adrenaline) if required.

The tracheal route is not recommended but if it is used, it is highly likely that doses of 50–100 micrograms kg⁻¹ will be required.^{3,7,136,261–265} Neither the safety nor the efficacy of these higher tracheal doses has been studied. Do not give these high doses intravenously.

Bicarbonate

If effective spontaneous cardiac output is not restored despite adequate ventilation and adequate chest compressions, reversing intracardiac acidosis may improve myocardial function and achieve a spontaneous circulation. There are insufficient data to recommend routine use of bicarbonate in resuscitation of the newly born. The hyperosmolarity and carbon dioxide-generating properties of sodium bicarbonate may impair myocardial and cerebral function. Use of sodium bicarbonate is not recommended during brief CPR. If it is used during prolonged arrests unresponsive to other therapy, it should be given only after adequate ventilation and circulation is established with CPR. A dose of 1–2 mmol kg⁻¹ may be given by slow intravenous injection after adequate ventilation and perfusion have been established.

Fluids

If there has been suspected blood loss or the infant appears to be in shock (pale, poor perfusion, weak pulse) and has not responded adequately to other resuscitative measures then consider giving fluid.²⁶⁶ This is a rare event. In the absence of suitable blood (i.e. irradiated and leucocyte-depleted group O Rh-negative blood), isotonic crystalloid rather than albumin is the solution of choice for restoring intravascular volume. Give a bolus of 10 ml kg⁻¹ initially. If successful it may need to be repeated to maintain an improvement. When resuscitating preterm infants volume is rarely needed and has been associated with intraventricular and pulmonary haemorrhages when large volumes are infused rapidly.

Withholding or discontinuing resuscitation

Mortality and morbidity for newborns varies according to region and to availability of resources.²⁶⁷ Social science studies indicate that parents desire a larger role in decisions to resuscitate and to continue life support in severely compromised babies.²⁶⁸ Opinions vary amongst providers, parents and societies about the balance of benefits and disadvantages of using aggressive therapies in such babies.^{269,270} Local survival and outcome data are important in appropriate counselling of parents. A recent study suggests that the institutional approach at the border of viability affects the subsequent results in surviving infants.²⁷¹

Discontinuing resuscitation

Local and national committees will define recommendations for stopping resuscitation. If the heart rate of a newly born baby is not detectable and remains undetectable for 10 min, it may be appropriate to consider stopping resuscitation. The decision to continue resuscitation efforts when the heart rate has been undetectable for longer than 10 min is often complex and may be influenced by issues such as the presumed aetiology, the gestation of the baby, the potential reversibility of the situation, the availability of therapeutic hypothermia and the parents' previous expressed feelings about acceptable risk of morbidity.^{267,272–276} The decision should be individualised. In cases where the heart rate is less than 60 min⁻¹ at birth and does not improve after 10 or 15 min of continuous and

apparently adequate resuscitative efforts, the choice is much less clear. In this situation there is insufficient evidence about outcome to enable firm guidance on whether to withhold or to continue resuscitation.

Withholding resuscitation

It is possible to identify conditions associated with high mortality and poor outcome, where withholding resuscitation may be considered reasonable, particularly when there has been the opportunity for discussion with parents.^{38,272,277–282} There is no evidence to support the prospective use of any particular delivery room prognostic score presently described, over gestational age assessment alone, in preterm infants <25 weeks gestation.

A consistent and coordinated approach to individual cases by the obstetric and neonatal teams and the parents is an important goal.²⁸³ Withholding resuscitation and discontinuation of life-sustaining treatment during or following resuscitation are considered by many to be ethically equivalent and clinicians should not be hesitant to withdraw support when the possibility of functional survival is highly unlikely. The following guidelines must be interpreted according to current regional outcomes.

- Where gestation, birth weight, and/or congenital anomalies are associated with almost certain early death, and unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated.^{38,277,284} Examples from the published literature include: extreme prematurity (gestational age less than 23 weeks and/or birth weight less than 400 g), and anomalies such as anencephaly and confirmed Trisomy 13 or 18.
- Resuscitation is nearly always indicated in conditions associated with a high survival rate and acceptable morbidity. This will generally include babies with gestational age of 25 weeks or above (unless there is evidence of fetal compromise such as intrauterine infection or hypoxia-ischaemia) and those with most congenital malformations.
- In conditions associated with uncertain prognosis, where there is borderline survival and a relatively high rate of morbidity, and where the anticipated burden to the child is high, parental desires regarding resuscitation should be supported.²⁸³
- When withdrawing or withholding resuscitation, care should be focused on the comfort and dignity of the baby and family.

Communication with the parents

It is important that the team caring for the newborn baby informs the parents of the baby's progress. At delivery, adhere to the routine local plan and, if possible, hand the baby to the mother at the earliest opportunity. If resuscitation is required inform the parents of the procedures undertaken and why they were required.

European guidelines are supportive of family presence during cardiopulmonary resuscitation.²⁸⁵ In recent years healthcare professionals are increasingly offering family members the opportunity to remain present during CPR and this is more likely if resuscitation takes place within the delivery room. Parents' wishes to be present during resuscitation should be supported where possible.²⁸⁶

The members of the resuscitation team and family members, without coercion or pressure, make the decision about who should be present during resuscitation jointly. It is recommended to provide a healthcare professional whose sole responsibility is to care for the family member. Whilst this may not always be possible it should not mean the exclusion of the family member from the resuscitation. Finally, there should be an opportunity for the immediate relative to reflect, ask questions about details of the resuscitation and be informed about the support services available.²⁸⁶

Decisions to discontinue resuscitation should ideally involve senior paediatric staff. Whenever possible, the decision to attempt resuscitation of an extremely preterm baby should be taken in close consultation with the parents and senior paediatric and obstetric staff. Where a difficulty has been foreseen, for example in the case of severe congenital malformation, discuss the options and prognosis with the parents, midwives, obstetricians and birth attendants before delivery.²⁸³ Record carefully all discussions and decisions in the mother's notes prior to delivery and in the baby's records after birth.

Post-resuscitation care

Babies who have required resuscitation may later deteriorate. Once adequate ventilation and circulation are established, the infant should be maintained in or transferred to an environment in which close monitoring and anticipatory care can be provided.

Glucose

Hypoglycaemia was associated with adverse neurological outcome in a neonatal animal model of asphyxia and resuscitation.²⁸⁷ Newborn animals that were hypoglycaemic at the time of an anoxic or hypoxic-ischaemic insult had larger areas of cerebral infarction and/or decreased survival compared to controls.^{288,289} One clinical study demonstrated an association between hypoglycaemia and poor neurological outcome following perinatal asphyxia.²⁹⁰ In adults, children and extremely low-birth-weight infants receiving intensive care, hyperglycaemia has been associated with a worse outcome.^{288–292} However, in paediatric patients, hyperglycaemia after hypoxia-ischaemia does not appear to be harmful,²⁹³ which confirms data from animal studies²⁹⁴ some of which suggest it may be protective.²⁹⁵ However, the range of blood glucose concentration that is associated with the least brain injury following asphyxia and resuscitation cannot be defined based on available evidence. Infants who require significant resuscitation should be monitored and treated to maintain glucose in the normal range.

Induced hypothermia

Newly born infants born at term or near-term with evolving moderate to severe hypoxic - ischemic encephalopathy should, where possible, be offered therapeutic hypothermia.^{296–301} Whole body cooling and selective head cooling are both appropriate strategies. Cooling should be initiated and conducted under clearly defined protocols with treatment in neonatal intensive care facilities and with the capabilities for multidisciplinary care. Treatment should be consistent with the protocols used in the randomized clinical trials (i.e. commence within 6 h of birth, continue for 72 h of birth and re-warm over at least 4 h). Animal data would strongly suggest that the effectiveness of cooling is related to early intervention. There is no evidence in human newborns that cooling is effective if started more than 6 h after birth. Commencing cooling treatment >6 h after birth is at the discretion of the treating team and should only be on an individualised basis. Carefully monitor for known adverse effects of cooling such as thrombocytopenia and hypotension. All treated infants should be followed longitudinally.

Prognostic tools

The Apgar score was proposed as a "simple, common, clear classification or grading of newborn infants" to be used "as a basis for discussion and comparison of the results of obstetric practices, types of maternal pain relief and the effects of resuscitation" (our emphasis).¹⁰⁶ Although widely used in clinical practice, for research purposes and as a prognostic tool,³⁰² its applicability has been questioned due to large inter- and intra-observer variations. These are partly explained by a lack of agreement on how to score infants receiving medical interventions or being born

preterm. Therefore a development of the score was recommended as follows: all parameters are scored according to the conditions regardless of the interventions needed to achieve the condition and considering whether being appropriate for gestational age. In addition, the interventions needed to achieve the condition have to be scored as well. This Combined-Apgar has been shown to predict outcome in preterm and term infants better than the conventional score.^{303,304}

Briefing/debriefing

Prior to resuscitation it is important to discuss the responsibilities of each member of the team. After the management in the delivery room a team debrief of the event using positive and constructive critique techniques should be conducted and personal bereavement counselling offered to those with a particular need. Studies of the effect of briefings or debriefings following resuscitation have generally shown improved subsequent performance.^{305–310} However, many of these have been following simulation training. A method that seems to further improve the management in the delivery room is videotaping and subsequent analysis of the videos.³¹¹ A structured analysis of perinatal management with feedback has been shown to improve outcomes, reducing the incidence of intraventricular haemorrhage in preterm infants.³¹²

Regardless of the outcome, witnessing the resuscitation of their baby may be distressing for parents. Every opportunity should be taken to prepare parents for the possibility of a resuscitative effort when it is anticipated and to keep them informed as much as possible during and certainly after the resuscitation. Whenever possible, information should be given by a senior clinician. Early contact between parents and their baby is important.

Conflicts of interest

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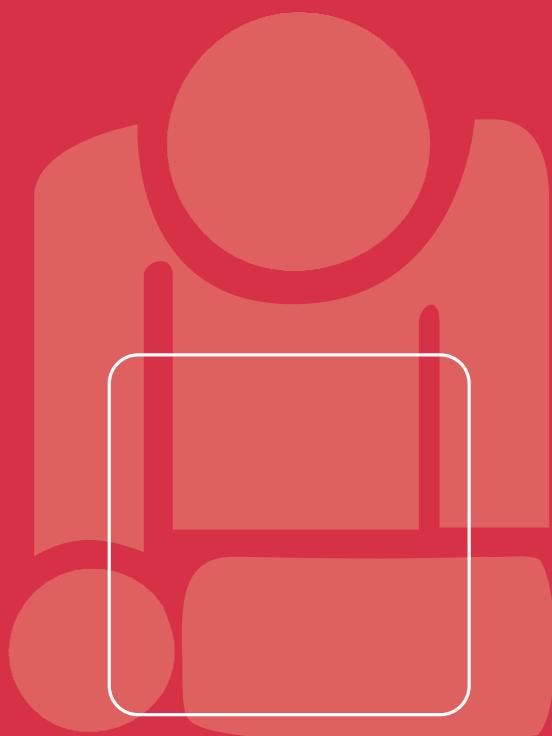
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Reanimatie en ondersteuning van de transitie van het kind bij de geboorte

8



Reanimatie en ondersteuning van de transitie van het kind bij de geboorte

Introductie

Dit hoofdstuk bevat de richtlijn voor professionele hulpverleners bij de reanimatie en ondersteuning van de transitie van het kind direct na de geboorte. Deze richtlijn is bedoeld voor het kind direct na de geboorte, ook wel omschreven als de 'natte' pasgeborene. Het gaat om een bewerking van de European Resuscitation Council Guidelines for Resuscitation 2015: "Section 7. Resuscitation and support of transition of babies at birth".

Veranderingen in de richtlijnen reanimatie en ondersteuning van de transitie van het kind bij de geboorte.

- Ondersteuning van de transitie: deze term wordt geïntroduceerd om de unieke situatie bij de geboorte te benadrukken. Pasgeborenen hebben zelden reanimatie nodig, maar wel ondersteuning bij de transitie.
- Afklemmen van de navelsteng: voor onbedreigde preterme en a terme pasgeborenen wordt geadviseerd minimaal 1 minuut te wachten met het afklemmen van de navelsteng na de complete geboorte van het kind. Voor ernstig bedreigde pasgeborenen is er vooralsnog onvoldoende bewijs om het juiste moment voor het afklemmen van de navelsteng te adviseren.
- Optimale beoordeling van de hartfrequentie: het ECG is een snelle en betrouwbare manier om de hartfrequentie te bepalen.
- Lucht/zuurstof: voor a terme pasgeborenen moet kamerlucht gebruikt worden bij reanimatie. Als, ondanks adequate beademing, herstel van hartactie en oxygenatie (bij voorkeur gemeten met een saturatiemeter) uitblijft, moet toediening van extra zuurstof overwogen worden. Bij preterme pasgeborenen met een zwangerschapsduur van minder dan 35 weken kan ademhalingsondersteuning gestart worden met kamerlucht of 30% zuurstof.

- CPAP: bij spontaan ademende preterme pasgeborenen met verhoogde ademarbeid heeft initieel CPAP als ademhalingsondersteuning de voorkeur boven intubatie.
- Inflatiebeademingen: bij a terme pasgeborenen worden initieel 5 inflatiebeademingen met een druk van 30 cm water gegeven. Bij preterme pasgeborenen blijft de druk 20-25 cm water.
- Temperatuur: de temperatuur van pasgeborenen moet gehandhaafd worden tussen 36,5 °C en 37,5 °C. In de richtlijn wordt het belang hiervan benadrukt vanwege de sterke associatie met mortaliteit en morbiditeit. De opnametemperatuur moet worden geregistreerd als een kwaliteitsindicator en als prognostische factor.
- Temperatuurbeleid bij preterme pasgeborenen: bij preterme pasgeborenen met een zwangerschapsduur van minder dan 32 weken is soms een combinatie van interventies noodzakelijk om de temperatuur tussen 36,5 °C en 37,5 °C te handhaven. Tot deze interventies kunnen behoren: het verwarmen en bevochtigen van beademingsgassen, het verhogen van de kamertemperatuur, het gebruik van de plastic zak en gebruik van een warmtematras. Deze maatregelen zijn effectief in het voorkomen van hypothermie.
- Meconium: bij een slappe, niet ademende pasgeborene met meconiumhoudend vruchtwater wordt niet langer geadviseerd om endotracheaal uit te zuigen (dit gebeurt alleen bij verdenking op tracheale obstructie). De nadruk moet liggen op starten met beademen binnen de eerste minuut na geboorte. Dit mag niet worden uitgesteld.
- Thoraxcompressies: het is acceptabel om na de inflatiebeademingen tot maximaal 30 seconden te ventileren alvorens te starten met thoraxcompressies.
- Natriumbicarbonaat: natriumbicarbonaat wordt niet meer aanbevolen bij reanimatie van pasgeborenen.

Achtergrond

Een kleine groep van kinderen heeft ondersteuning nodig bij de perinatale transitie, meestal bestaande uit hulp bij de ademhaling. Slechts een kleine minderheid van de kinderen heeft naast beademing een korte periode van thoraxcompressies of medicamenteuze ondersteuning nodig.

In Nederland is begeleiding van zwangerschap en bevalling gebaseerd op risicoselectie. Tijdens regelmatige zwangerschapscontroles wordt op basis van een inschatting van de risico's voor moeder en/of kind bepaald waar en onder welke omstandigheden de bevalling het beste kan plaatsvinden en/of verwijzing naar de tweede of derde lijn nodig is. Afhankelijk van de omgeving waar de bevalling plaatsvindt, worden moeder en kind bijgestaan door hulpverleners van uiteenlopende

disciplines. In alle situaties kan (onverwacht) een reanimatie nodig zijn. Dit betekent dat de verschillende hulpverlener(s) de basale reanimatievaardigheden moeten beheersen. Bij een thuisbevalling moet de kwaliteit van de opvang en eventuele reanimatie of ondersteuning van de transitie van de pasgeborene gegarandeerd zijn. Idealiter moeten 2 getrainde hulpverleners aanwezig zijn, waarvan 1 voldoende vaardig is in masker- en ballonbeademing en thoraxcompressies, en getraind is in newborn life support.

Afhankelijk van de inschatting van de kans dat reanimatie van het kind bij de geboorte nodig zal zijn, kunnen de volgende situaties onderscheiden worden:

- Bij een bevalling zonder verhoogd risico moet diegene die de bevalling leidt, de vaardigheden van basic life support beheersen.
- Bij een sectio caesarea is de kinderarts te allen tijde verantwoordelijk voor de opvang van de pasgeborene, ongeacht de indicatie voor de sectio. Van deze regel kan op lokaal niveau, in goed overleg tussen gynaecologen, kinderartsen en anesthesiologen, worden afgeweken.
- Bij een bevalling met een verhoogd risico, begint de voorbereiding voor de partus met goede communicatie over - en overdracht van - de relevante perinatale gegevens van moeder en kind. Bij de bevalling moeten 2 hulpverleners aanwezig zijn, die de vaardigheden voor newborn life support beheersen. Als naast beademing ook thoraxcompressie en/of medicatiotoediening noodzakelijk zijn, is een team van minimaal 3 hulpverleners gewenst.
- Een bevalling van een meerling heeft per definitie een verhoogd risico. Voor ieder kind is een team van 2 hulpverleners gewenst.

Voor alle aanwezige hulpverleners bij een bevalling geldt dat zij geschoold moeten zijn in de van hen te verwachten vaardigheden. Een gestructureerde cursus in reanimatie van de pasgeborene is essentieel voor de medewerkers in ieder instituut waar bevallingen plaatsvinden. Regelmatische nascholing is noodzakelijk om de vaardigheden te onderhouden.

Voorbereiding

Zorg voor een tochtvrije en warme opvangkamer (streef naar 23 °C tot 25 °C en bij preterme pasgeborenen < 28 weken zwangerschapsduur, streef naar > 25 °C).

Controleer de apparatuur en leg de benodigde materialen klaar. Brief het team over de te verwachten situatie. Spreek van tevoren de rolverdeling af. Wacht bij onbedreigde pasgeborenen minimaal 1 minuut met het afklemmen van de navelstreng.

Reanimatie bij de geboorte

(antenatale counseling) Team briefing en controle materialen

geboorte

Droog de pasgeborene af

Verwijder natte doeken. Dek toe. Start de klok of noteer de tijd

Evalueer hartfrequentie, ademhaling, kleur (en tonus)

60 seconden

Bij gaspen of apnoe:

Luchtweg openen, geef 5 inflatiebeademingen

Overweeg $SpO_2 \pm ECG$ monitoring

Evalueer

Indien geen stijging hartfrequentie kijk naar thoraxexcursies

aanvaardbare
predictale
 SpO_2 waarden
2 min: 60%
3 min: 70%
4 min: 80%
5 min: 85%
10 min: 90%

Indien geen thoraxexcursies:

Controleer opnieuw hoofdpositie

Overweeg 2-persoons techniek of andere luchtwegmanoeuvres

Herhaal inflatiebeademingen

$SpO_2 \pm ECG$ monitoring

Evalueer

Indien geen stijging van hartfrequentie:

Kijk naar thoraxexcursies

Pas zuurstof aan op geleide
van saturatiemeter

Indien overtuigd van thoraxexcursies:

Start bij een hartfrequentie <60/min na 30 seconden beademing met thoraxcompressies en geef extra zuurstof.

3 compressies op 1 beademing

Evalueer hartfrequentie elke 30 seconden

Indien hartfrequentie <60/min

Zorg voor i.v. toegang en geef adrenaline

Endotracheale intubatie kan op verschillende
momenten worden overwogen

Informeer ouders en debrief met team

VRAAG U OP ELK MOMENT AF OF U HULP NODIG HEEFT

Let op temperatuur

Volgorde van handelen

1 Initiële handelingen

De initiële handelingen bestaan uit het starten van de klok, maatregelen ter voorkoming van afkoeling, eerste evaluatie en, indien nodig, het inroepen van hulp. Pasgeborenen zijn klein, nat en de longen zijn gevuld met vocht. Ze koelen snel af, vooral als ze nat blijven en op de tocht liggen. Afkoeling verhoogt de morbiditeit en mortaliteit.

- Verwijder nat linnengoed onmiddellijk.
- Droog de pasgeborene af en bedek het hoofd met een muts. Afdrogen geeft meestal voldoende stimulatie om de ademhaling op gang te brengen. Wikkel het kind in warme doeken of leg het huid-op-huid op de borst of buik van de moeder en bedek de rug en het hoofd van het kind met warme doeken.
- Bij premature geboorte bij een zwangerschapsduur van minder dan 32 weken wordt de pasgeborene met uitzondering van het hoofd in een plastic zak geplaatst, zonder het kind vooraf af te drogen. Leg de pasgeborene onder een stralingswarmtebron. Droog het hoofd af en bedek het met een muts.
- Bij preterm pasgeborenen met een zwangerschapsduur van minder dan 32 weken is soms een combinatie van interventies noodzakelijk om de temperatuur tussen 36,5 °C en 37,5 °C te handhaven. Tot deze interventies kunnen behoren: het verwarmen en bevochtigen van beademingsgassen, het verhogen van de kamertemperatuur, het gebruik van de plastic zak en gebruik van een warmtematras. Deze maatregelen zijn effectief in het voorkomen van hypothermie. Monitor de temperatuur ook om hyperthermie te voorkomen, omdat hyperthermie is geassocieerd met verhoogde morbiditeit en mortaliteit.

Evaluatie

- Beoordeel tijdens het afdrogen de kleur, tonus en ademhaling. Beoordeel ook de hartfrequentie van de pasgeborene met een stethoscoop. Palpatie van de navelstreng is alleen betrouwbaar als de pulsaties boven de 100/min zijn. Bevestig, indien beschikbaar, een saturatiemeter bij voorkeur aan de rechterhand of pols van de pasgeborene. Bij pasgeborenen die reanimatie of ademhalingsondersteuning nodig hebben, is het monitoren van de hartfrequentie met ECG sneller en betrouwbaarder dan met een saturatiemeter.
- Evalueer de kleur, tonus, ademhaling en hartfrequentie gedurende de reanimatie iedere 30 seconden totdat de pasgeborene gestabiliseerd is. Het stijgen van de hartfrequentie is het eerste teken van verbetering.
- Overweeg of u hulp nodig heeft.

- Start beademing bij pasgeborenen met een insufficiënte ademhaling (irregulair of afwezig) en een hartfrequentie < 100/min.

De apgarscore is geïntroduceerd om de klinische conditie van de pasgeborene postpartum snel te kunnen beoordelen. De apgarscore is niet ontwikkeld om de reactie op een reanimatie te beoordelen. Strikt genomen zijn alleen de vitale parameters ademhaling en hartfrequentie nodig om de noodzaak tot reanimatie te bepalen.

2 Luchtweg

Bij pasgeborenen die reanimatie of ondersteuning bij de transitie nodig hebben, zijn het openen van de luchtweg en het adequaat ventileren van de longen meestal voldoende voor herstel.

- Leg de pasgeborene op zijn rug met het hoofd in neutrale positie, (Figuur 1). Een doek onder de schouders kan hierbij van nut zijn.

Als dit niet effectief is, kunnen de volgende methoden gebruikt worden om de luchtweg te openen:

- Herpositioneer en controleer of het masker goed aansluit op het gezicht.
- Pas jaw thrust toe, indien mogelijk met 2 personen.
- Breng een orofaryngeale airway in (Mayo of Guedel).
- Zuig uit onder direct zicht. Uitzuigen kan leiden tot een vertraging van spontane ademhaling, laryngospasme en vagale bradycardie.
- Als bovenstaande methoden niet effectief zijn, kan het gebruik van een larynxmasker overwogen worden.
- Overweeg bij een slappe, niet-ademende pasgeborene met meconiumhoudend vruchtwater de orofarynx te inspecteren om meconium te verwijderen en eventuele luchtwegobstructie op te heffen.

Figuur 1

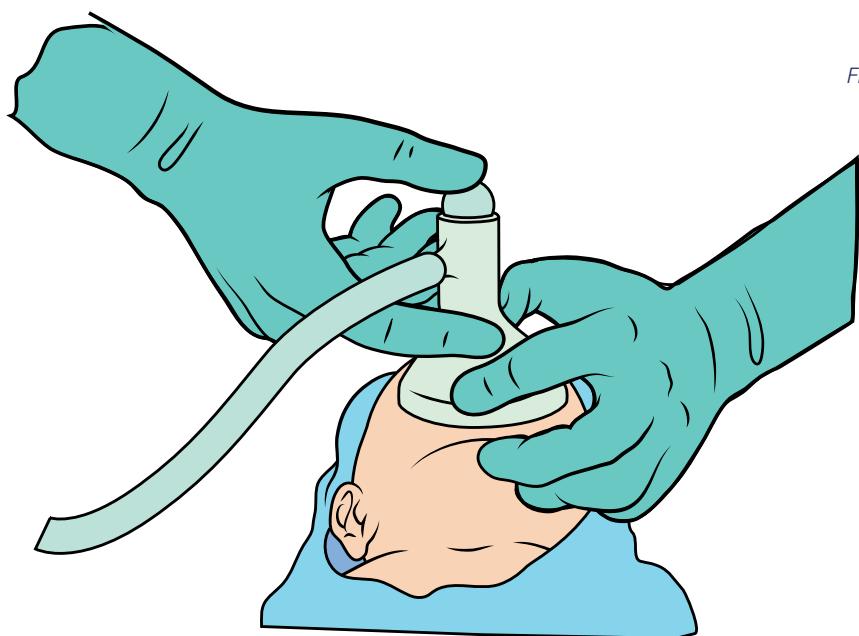


3 Ademhaling

Als de pasgeborene na het openen van de luchtweg niet spontaan ademt, moet gestart worden met beademing.

- Geef initieel **5 inflatiebeademingen** met een druk van 30 cm water bij à terme en 20-25 cm water bij preterme pasgeborenen gedurende 2-3 seconden met kamerlucht, (Figuur 2). Bij preterme pasgeborenen met een zwangerschapsduur van minder dan 35 weken kan ademhalingsondersteuning gestart worden met kamerlucht of 30% zuurstof.
- Kijk naar de borstkas bij iedere inflatiebeademing. Bewegingen van de borstkas zijn een aanwijzing voor adequate ventilatie, maar deze zijn niet altijd goed zichtbaar.
- Als de hartfrequentie stijgt, kunt u er zeker van zijn dat u de longen heeft ontplooid.
- Als de hartfrequentie stijgt, maar de pasgeborene nog niet zelf ademt, beadem dan met een frequentie van 30-60/min. Ga door tot de pasgeborene wel zelfstandig ademt.
- Bij spontaan ademende preterme pasgeborenen met verhoogde ademarbeid, heeft initieel CPAP als ademhalingsondersteuning de voorkeur boven intubatie.
- Als de hartfrequentie niet stijgt en geen thoraxexcursies zichtbaar zijn is de meest waarschijnlijke oorzaak een niet-vrije ademweg of inadequate ventilatie door lekkage langs het masker of obstructie. Overweeg dan de bij de luchtweg genoemde alternatieve methoden voor het openen van de luchtweg.

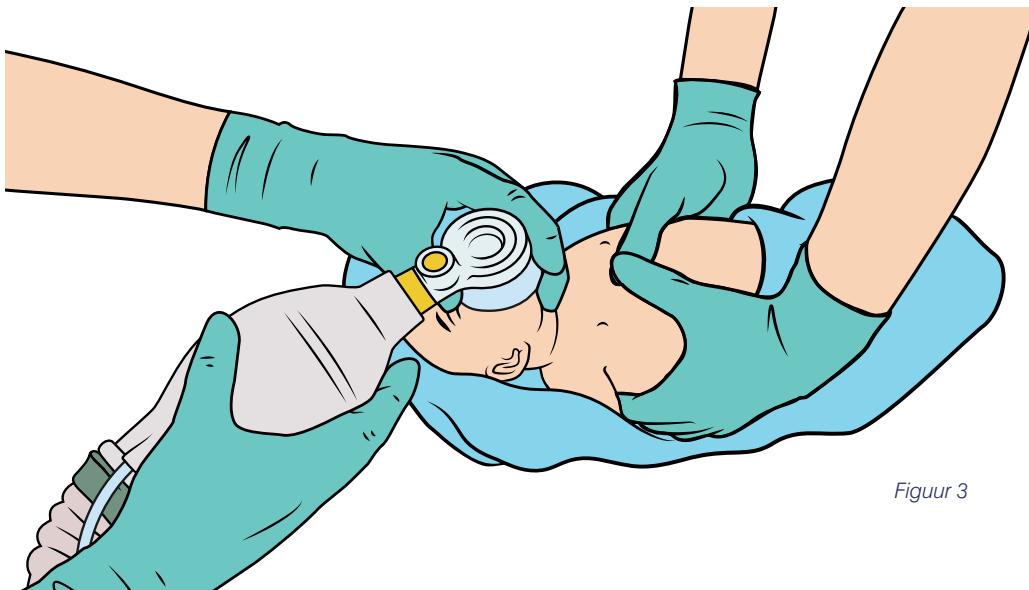
Figuur 2



- Start thoraxcompressies als de hartfrequentie niet stijgt en onder de 60/min blijft ondanks effectieve beademing. U dient maximaal 30 seconden te ventileren alvorens te starten met thoraxcompressies. Dit geeft de tijd om zeker te zijn van adequate ventilatie en om de pasgeborene te laten herstellen van de bradycardie.

4 Thoraxcompressies

- Start thoraxcompressies alleen als u zeker weet dat u de longen goed hebt ontplooid.
- Omvat met beide handen de borstkas, plaats uw duimen naast of op elkaar op het onderste derde deel van het borstbeen, (Figuur 3).
- Druk de borstkas minstens een derde van de diepte van de borstkas in. Zorg ervoor dat de borstkas na iedere compressie weer volledig omhoog komt, maar haal uw duimen niet van het sternum af.
- De verhouding tussen thoraxcompressie en ventilatie bij pasgeborenen is 3:1.
- Geef 90 thoraxcompressies en 30 beademingen (dus 120 handelingen per minuut). Echter, de kwaliteit van de ventilatie en de thoraxcompressies is belangrijker dan de exacte frequentie.
- Controleer de hartfrequentie elke 30 seconden. Als de hartfrequentie boven de 60/min stijgt, kunnen de thoraxcompressies gestaakt worden.
- Verhoog de zuurstofconcentratie bij het starten van thoraxcompressies en pas die indien mogelijk aan op geleide van de saturatiemeter.

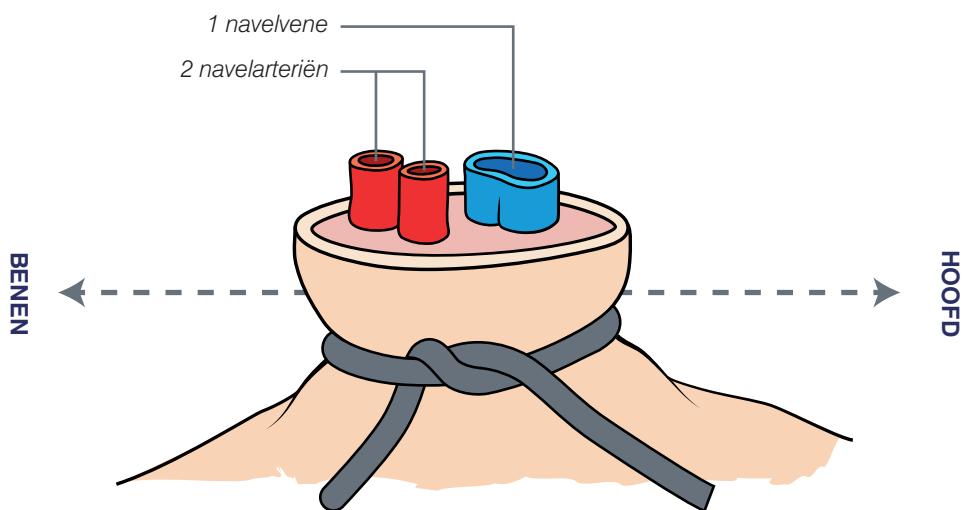


Figuur 3

5 Medicatie

Medicatie is zelden nodig bij neonatale reanimatie. Incidenteel zijn inflatiebeademingen en hartmassage niet voldoende om de circulatie op gang te krijgen. In deze situatie moet het toedienen van medicatie overwogen worden, bij voorkeur via een navelvenekatheter.

- Adrenaline moet bij voorkeur intraveneus toegediend worden, in een dosis van 10 tot 30 microgram/kg. Vergeet niet de navelvenekatheter na te flushen met 2 ml NaCl 0.9%.
- Als er geen intraveneuze toegang mogelijk is, kan adrenaline endotracheaal toegediend worden in een dosis van 50-100 microgram/kg.
- Bij verdenking op hypovolemische shock en onvoldoende reactie ondanks adequate reanimatiehandelingen moet een vloeistofbolus gegeven worden. Als geschikt bloed niet snel vorhanden is, gebruik dan fysiologisch zout in een dosis van 10 ml per kg in 1-5 minuten. Herhaal dit zo nodig. Het gebruik van een vloeistofbolus bij preterme pasgeborenen is zelden noodzakelijk en is geassocieerd met intraventriculaire bloedingen en longbloedingen.
- Er is onvoldoende bewijs om natriumbicarbonaat aan te bevelen bij reanimatie van pasgeborenen.
- Controleer en monitor zo spoedig mogelijk de bloedglucose en start een continu glucose-infusus (4-6 mg/kg/min).



Figuur 4

Nadere toelichting bij de richtlijnen

Medicatie

Medicatie wordt bij voorkeur intraveneus via een navelvenekatheter gegeven, (Figuur 4). Het inbrengen van een perifeer infuus wordt afgeraden tijdens een reanimatie, in verband met de lage slagingskans en effectiviteit. Als de hulpverlener de techniek van het inbrengen van een navelvenekatheter niet beheert, kan een botnaald gebruikt worden. Er moet rekening gehouden worden met risico's van botnaalden (onder andere subcutane necrose door extravasatie, osteomyelitis, huidinfectie, vetembolie, fracturen, compartimentsyndroom bij langdurige intraossale infusie), met name bij preterme pasgeborenen.

Meconium

Bij meconiumhoudend vruchtwater wordt het intrapartum uitzuigen, dat is het uitzuigen van neus en mond van de zuigeling direct na de geboorte van het hoofd, niet aanbevolen. Bij een slappe, niet-ademende pasgeborene met meconiumhoudend vruchtwater wordt niet langer geadviseerd om endotracheaal uit te zuigen (dit gebeurt alleen bij verdenking op tracheale obstructie). De nadruk moet liggen op starten met beademen binnen de eerste minuut na geboorte. Dit mag niet worden uitgesteld. Overweeg bij een slappe, niet-ademende pasgeborene met meconiumhoudend vruchtwater de orofarynx te inspecteren om meconium te verwijderen en een eventuele luchtwegobstructie op te heffen.

De in 2010 geformuleerde richtlijn om de pasgeborene eerst toe te dekken, de trachea uit te zuigen en daarna af te drogen, komt hierbij te vervallen. De pasgeborene wordt meteen na de geboorte afgedroogd, zowel zonder als met meconiumhoudend vruchtwater.

Zuurstof of kamerlucht?

À terme pasgeborene

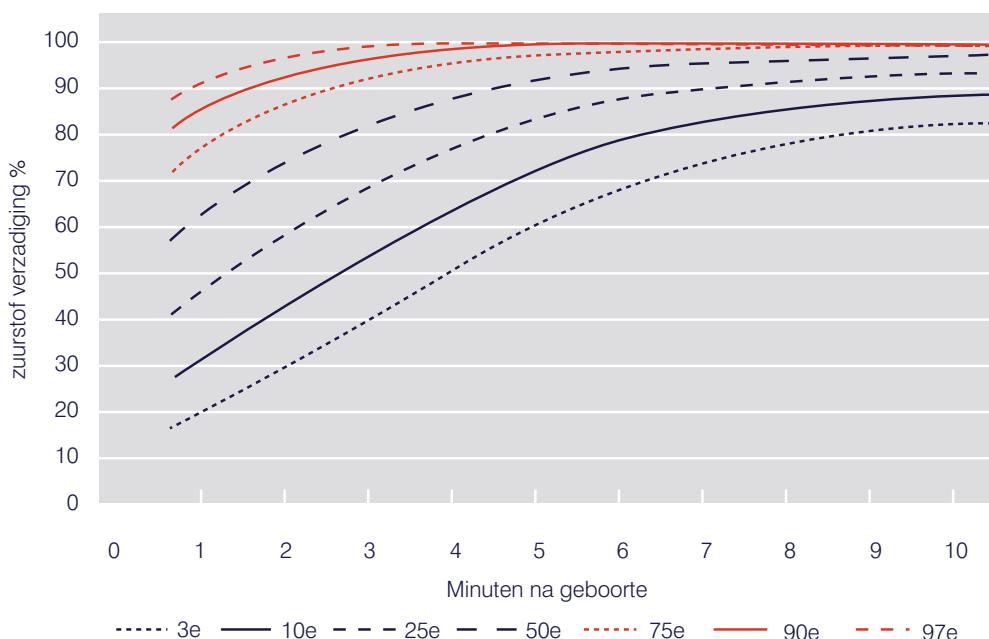
Bij de initiële beademing moet gestart worden met kamerlucht. Bij voorkeur wordt de zuurstofsaturatie gemeten met een saturatiemeter en kan extra zuurstof toegediend worden op geleide van de beschikbare saturatiecurves, (Algoritme en Figuur 5). Bij het starten van thoraxcompressies moet de zuurstofconcentratie verhoogd worden, indien mogelijk op geleide van de saturatiemeter.

Preterme pasgeborene

Preterme pasgeborenen met een zwangerschapsduur van minder dan 35 weken bereiken met kamerlucht soms niet dezelfde zuurstofverzadiging als à terme pasgeborenen. Om deze reden kan ademhalingsondersteuning gestart worden met kamerlucht of 30% zuurstof. Op geleide van zuurstofsaturaties gemeten met een saturatiemeter moet de zuurstoftoediening getitreerd worden, waarbij hypoxemie én hyperoxemie vermeden moeten worden.

Als geen mengkraan voor zuurstof en kamerlucht beschikbaar is, moet gestart worden met kamerlucht en niet met 100% zuurstof.

Figuur 5



Inflatiebeademingen

Dierstudies suggereren dat initiële beademingen met een langere inspiratietijd dan 5 seconden de functionele residuale capaciteit kunnen verbeteren. Humane studies tonen aan dat hiermee de noodzaak tot beademing afneemt zonder reductie in mortaliteit, bronchopulmonale dysplasie of pneumothorax. Er zijn echter nog onvoldoende gegevens over de veiligheid, de duur van de inflatiebeademingen, de benodigde drukken en de langetermijneffecten. Er is daarom nog onvoldoende

bewijs om het advies over de duur van inflatiebeademingen te veranderen in langer dan 3 seconden.

Intubatie van de trachea

Intubatie is zelden nodig bij de opvang van de pasgeborene. Intubatie vereist training en ervaring, en kan op verschillende momenten tijdens de reanimatie worden overwogen:

- tijdens uitzuigen van dik meconium bij verdenking op een intra-tracheale obstructie;
- als positieve drukbeademing met masker niet effectief is;
- als langdurige beademing nodig is;
- als thoraxcompressies worden gegeven;
- bij specifieke omstandigheden bijvoorbeeld hernia diaphragmatica of om surfactant toe te dienen.

De juiste positie van de endotracheale tube moet na intubatie gecontroleerd worden. Naast de klinische beoordeling (hartfrequentiestijging, thoraxexcursies) wordt het registreren van uitgeademde CO₂ geadviseerd, ter bevestiging van endotracheale tubeplaatsing. Deze laatste methode is niet betrouwbaar bij een circulatiestilstand.

Larynxmasker

Uit studies blijkt dat larynxmaskers effectief kunnen zijn voor het beademen van pasgeborenen met een gewicht van meer dan 2000 gram en een zwangerschapsduur van meer dan 34 weken. Het gebruik van een larynxmasker is niet onderzocht bij preterme pasgeborenen met een gewicht onder 2000 gram of met een zwangerschapsduur onder de 34 weken, bij meconiumhoudend vruchtwater, bij thoraxcompressies en bij het toedienen van endotracheale medicatie.

Starten, niet starten en stoppen van reanimatie

Reanimatie is niet geïndiceerd in situaties waarbij sprake is van een te verwachten hoge mortaliteit of ernstige morbiditeit met kleine kans op overleving. In Nederland starten professionele hulpverleners de reanimatie meestal niet bij een of meer van de volgende criteria:

- een vastgestelde zwangerschapsduur < 24 weken;
- anencefalie;
- vastgestelde trisomie 13 of 18

Het is zeer onwaarschijnlijk dat de reanimatie van een pasgeborene na 10 minuten zonder eigen circulatie nog zal leiden tot overleving of overleving zonder ernstige handicap. In geval van een persisterende bradycardie < 60/min ondanks adequate

reanimatie zijn er onvoldoende gegevens beschikbaar om een aanbeveling te doen over het staken van de reanimatie. Een ervaren lid van het reanimatieteam neemt de beslissing om de reanimatie te staken.

Post-reanimatiebehandeling

Monitoring

Pasgeborenen kunnen na een succesvolle reanimatie op een later tijdstip alsnog verslechteren. Daarom moeten pasgeborenen na een reanimatie opgenomen worden op een afdeling voor monitorbewaking van hartfrequentie, ademhaling, zuurstofverzadiging en bloeddruk. Verder moeten bloedglucose en zuur/base-evenwicht gevolgd worden.

Therapeutische hypothermie

Therapeutische hypothermie kan neurologische schade na verdenking op hypoxische schade beperken. Bij pasgeborenen met een zwangerschapsduur van ten minste 36 weken en matige tot ernstige hypoxisch-ischemische encefalopathie moet, indien mogelijk, binnen 6 uur na de geboorte op basis van specifieke criteria therapeutische hypothermie gestart worden. Deze behandeling wordt alleen toegepast in gespecialiseerde centra en bestaat uit afkoeling tot 33,5 °C graden gedurende 72 uur.

Verschillen ten opzichte van de ERC-richtlijn

- De criteria voor het niet starten van reanimatie bij extreme prematuriteit: In Nederland wordt niet gestart met reanimatie bij pasgeborenen met een zwangerschapsduur van minder dan 24 weken.
- Het gebruik van een botnaald als toegang voor medicatie en vocht is in de NRR-richtlijn toegevoegd.
- Ventilatiebeademingen: in de NRR-richtlijn wordt een frequentie geadviseerd van 30-60/min en in de ERC-richtlijn 30/min.
- In de NRR-Richtlijn dient na de inflatiebeademingen 30 seconden te worden geventileerd alvorens te starten met thoraxcompressies.
- In de ERC-richtlijn wordt geadviseerd de temperatuur te handhaven tussen 36,5 °C en 37,5 °C bij niet-asfyctische pasgeborenen. In de NRR-richtlijn wordt dit onderscheid niet gemaakt en geldt dit advies voor alle pasgeborenen.
- In de ERC-richtlijn wordt het gebruik van natriumbicarbonaat nog genoemd ter overweging bij langdurige reanimatie. In de NRR-richtlijn wordt natriumbicarbonaat niet meer geadviseerd.

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Saturday May 28, 2005

14:00-14:45

PETER DIECKMANN^(1,2)

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Room R

*General principles of managing critical situations
and preventing errors in anesthesia and intensive care medicine*

ERRORS IN MEDICINE, PATIENT SAFETY AND HUMAN FACTORS

“Safety is a dynamic non-event” [1]

Safety Culture is “A collection of characteristics and attitudes in an organization, promoted by its leaders and internalized by its members, that makes safety an overriding priority” [2]

Patient safety in developed countries is good, but not good enough. According to the IOM-Report “To err is human”, between 44,000 and 98,000 people die from medical errors each year in the US [3]. Many more are damaged by medical errors. These numbers are similar for other countries. Many of these outcomes are not due to inadequate medical knowledge but to problems in transforming that knowledge into meaningful clinical actions under the real world conditions of patient care [4]. In complex working systems like anesthesia decisions have to be made under conditions of uncertainty and time pressure. Working in multiprofessional teams requires coordination and communication skills which are not taught in medical school. Up to 70% of all errors can be attributed to human factors. It is time for medicine to acknowledge this and to adopt strategies to prevent those human errors harming patients. One way of reducing human factor errors is the CRM (Crisis Resource Management) concept.

WHAT IS CRM?

Crisis Resource Management (CRM) was introduced in aviation and has proved successful in many other industries. Gaba and colleagues transferred and adapted CRM to medicine and called it Anesthesia Crisis Resource Management [4]. CRM aims to coordinate, utilise and apply all available resources to optimise patient safety and outcomes. Resources include all people involved with all their skills, abilities and attitudes – as well as their limitations, in addition to equipment. CRM begins before the crisis. All the principles that help in dealing with an acute crisis also help avoid the crisis in the first place. CRM is about capturing errors as soon as possible and minimizing the negative consequences of errors which have already occurred. Gaba, Howard and Fish developed key points of CRM for anesthesia and these were recently updated [5].

TABLE 1: CRM KEY POINTS⁵

1.	Know the environment
2.	Anticipate and plan
3.	Call for help early
4.	Exercise leadership and followership
5.	Distribute the workload
6.	Mobilize all available resources
7.	Communicate effectively
8.	Use all available information
9.	Prevent and manage fixation errors
10.	Cross (double) check
11.	Use cognitive aids
12.	Re-evaluate repeatedly
13.	Use good teamwork
14.	Allocate attention wisely
15.	Set priorities dynamically

(from Rall M, Gaba DM: Human Performance and Patient Safety, in Miller 6th edition 2005)

HOW TO APPLY KEY POINTS OF CRM

CRM key points are designed to focus your attention on factors which might improve patient safety. As you read through these principles you may think them trivial. Our experience with simulator training shows that applying these principles during routine work and especially during crises makes differences which are far from trivial. For each of these principles, think them through and ask yourself for each key point:

- How does it apply to your job and work environment (colleagues and organisation)?
- Which problems have you experienced in your work related to the key points?
- Which problems have you observed in other people's work?
- How could you improve that using the key point?
- How did you apply the key point so far?
- How could you improve your ability to use this key point?
- What problems or obstacles could you face in your real world?

CRM IN ACTION - THE CRM KEY POINTS

1. KNOW THE ENVIRONMENT!

Ideally crisis management begins before the crisis starts. One of the prerequisites of crisis resource management is to **know your resources**. Resources are **personnel** and **equipment** (software and hardware). It is important to know who can be asked for help, who is available at the different times (days, nights, weekends), how to find those helpers quickly and how long it will take before effective help is available. For equipment you need to know not only *what* you have and *where*, but also *how* to operate it. Think about infrequently used equipment and check it regularly. This can be done when reviewing possible crisis situations.

Remember: *Knowing the technical, human and organisational environment can help to reduce a lot of stress in crises. In critical situations it can make the difference between losing or saving a patient's life.*

2. ANTICIPATE AND PLAN

Anticipation is key for goal-oriented behaviour. Consider the requirements of a case in advance, think of what could be difficult and plan ahead for each possible difficulty. Also expect the unexpected! Be prepared. Mentally stay ahead of the game. Good pilots say "Always fly ahead of your plane!"

Remember: *Anticipation helps to avoid surprises. During crises you don't want surprises. Planning ahead takes out a lot of stress in those hot moments of excitement.*

3. CALL FOR HELP EARLY

Knowing your own limitations and calling for help is the sign of a strong character and competent person. Trying alone or toughing it out is dangerous for the patient and inappropriate. In an emergency or even a suspected emergency, you should call for help early rather than late. Help needs time to arrive. In a crisis there may be too much for the team on scene to handle alone. Make sure to know in advance who and how to call and how to use the help when it arrives.

Remember: *Calling for help early is not a sign of low self-confidence; it shows your respect and sense of responsibility for your patient's safety. "Heroes" are dangerous.*

4. EXERCISE LEADERSHIP AND FOLLOWERSHIP

A team needs a leader. Someone has to take command, distribute tasks and collect all the information. You need to get some insight into what it means to lead a team. Leadership is not about knowing more than everybody else, doing everything alone or putting other people down. Leadership is about coordinating and planning using clear communication. Followership means being a good and important team member; listening to what the team leader says, doing what is needed. It does not mean shutting off your own brain. Be assertive if you think the team leader makes wrong decisions. It is your responsibility to make sure the leader is aware of your concerns. If there are team problems discuss them – but after the event.

Remember: *Concentrate on what is right, not who is right. The team consists of leaders and followers. The leader's job is to coordinate and integrate, but all are equally responsible for the patient's well-being. The patient should never suffer from your team problems.*

5. DISTRIBUTE THE WORKLOAD

One of the main tasks of a team leader is the distribution of workload. Someone needs to define the tasks, check that they are properly carried out and that everything fits together. If possible the team leader should remain free of manual tasks in order to observe, gather information and delegate tasks. Team members should also actively look for things which need to be done. It is not a good team, if the team leader has to direct every team action.

Remember: *You can not and should not do it all alone. As a leader distribute and coordinate tasks, as a team member offer ideas and tasks and do what needs to be done.*

6. MOBILIZE ALL AVAILABLE RESOURCES

Think of everyone and everything that could help you to deal with the problem at hand. That includes people and technology embedded in the organizational processes. On the human side your knowledge and skills and your knowledge of your strengths and weaknesses are your most important resource. Resources are there to be used. It is foolish to manage a crisis alone when there are colleagues in the lounge drinking coffee, or to struggle with infusions when the level-one device is unused in the storage room.

Remember: *After a crisis you often realize that there were precious resources available if only you had mobilized them. This can be personnel (numbers and qualifications) or extended monitoring and equipment.*

7. COMMUNICATE EFFECTIVELY

Communication is key in crisis situations. Good team work depends on *everybody being on the same page*. Communication ensures that everybody knows what is going on, what needs to be done and what is already done. Communication can be difficult sometimes. Saying something is only communication if the message is received (see Table 2).

Remember: *Communication is important for both the sender and receiver of a message, no matter whether they lead or follow. Address people directly. Acknowledge what you heard and confirm when you have completed a task.*

TABLE 2: COMMUNICATION FLOW – CLOSE THE LOOP (FROM [5])

- | |
|--|
| <ul style="list-style-type: none">• Meant is not said• Said is not heard• Heard is not understood• Understood is not done |
|--|

8. USE ALL AVAILABLE INFORMATION

Medicine is complex because you have to integrate information from many different sources. Every bit of information can help you to understand your patient's status better and arrive at the correct diagnosis. Complete the picture by correlating all these different sources: clinical impression, patient's vital signs, information available from relatives (e.g. about drug therapy and coexisting diseases). Make yourself aware of vital sign trends.

Remember: *When treating or diagnosing a patient you have to consider all information sources available. The key is to integrate bits of information in your mental picture of the patient. Humans tend to seek (only) for confirming information. Deliberately seek out information which does not fit to your picture.*

9. PREVENT AND MANAGE FIXATION ERRORS

All human action is based on mental models of the current situation. If your model of the situation is not correct, neither will your actions be. Fixation errors stem from faulty but consistent models of a situation. This may mean sticking to a diagnosis - *This and only this* - not taking into account the (correct, but rare) alternative. It might mean neglecting one (maybe most severe) diagnosis - *Everything but this*. Or it might mean that you do not recognize the need to act in emergency mode - *Everything is OK*.

One principle of managing fixation errors is to get a new view on the situation, not biased by faulty previous assumptions. Try to get a second opinion from somebody not involved – take care not to tell them too much about your own view so you will not “infect” them. Deliberately change perspectives (physically or mentally) and try to look for information not fitting your picture of the situation. Step back and look at the situation as a whole as if you were entering the room for the first time. Imagine what one of your most respected colleagues would do in this situation.

Remember: *Fixation errors are errors in your mental model of the patient and the situation. So they are hard to catch and come in different styles. Knowing the enemy already helps to respond. Always rule out the worst case.*

10. CROSS (DOUBLE) CHECK

Cross checking means correlating what you know from different sources. Does the artefact in the ECG show up in the pulse oximetry too? Our memory fools us sometimes and always tries to make things fit consistently. Maybe it is not an artefact. Double checking is about making sure that what you remember you perceived is what you actually perceived. Sometimes the mind plays tricks - you think you did something but maybe you did not, because you just thought you did it. Or maybe you thought you stopped the infusion, but you turned it wide open. Touch devices to make sure they are in the desired state.

Remember: *Always think about errors – both your own and others (To err is human). Rechecking might help you to catch these errors. Correlate results and perform plausibility checks. Read the vital signs monitor with your fingertips. Eyes are sometimes faster than the brain.*

11. USE COGNITIVE AIDS

Cognitive aids come in different forms but serve similar functions. The big strength of humans – but also their big weakness – is that they tend to take short cuts, do not think systematically and are flexible. “What helps most of the time” will produce errors when things need to be done in a definite order without missing anything. That is why we design cars but robots build them the same way over and over again. Using checklists, common in other industries, might help to not forget important steps in diagnosis or treatment. If machines do maths better than us – why not let them do it? Calculating dosages using a calculator is less error prone than using your head. Looking up dosages or other information shows responsibility not a lack of knowledge. Calling hotlines (poisoning, malignant hyperpyrexia) is also a responsible action.

Remember: *Never feel bad looking something up, even if you knew it before. Check yourself. Have important information on paper. Don't be cool – be good. It might be a life and death decision!*

12. RE-EVALUATE REPEATEDLY

Acute medicine is dynamic. What is correct now might be wrong in the next minute. Every piece of information might change a situation. Some parameters might also change slowly over time. Subtle changes are hard to perceive. So do not hesitate to follow a dynamic situation by dynamic decision making – do not stick to choices you made if the situation changes. Use trend monitoring whenever possible in order to detect slowly falling blood pressure. Keeping track of trends is difficult for the human mind. Let technology help you.

Remember: *Be aware of dynamically changing situations. What is this patient's main problem and what most endangers his life? Be in doubt, try to correlate all information. Establish a habit of rechecking your mental model regularly.*

13. USE GOOD TEAMWORK

Not all team work is good work and good team work is hard work. Coordination of a team begins before it gathers. If all members know the tasks to be done and their roles during these tasks, coordination is easier. Short briefings at the beginning of a task are common in aviation and are time well spent. During a crisis there is often much tension within a team. Even though it is not a common part of current clinical practice, a debriefing provides a tremendous learning opportunity.

Remember: *Dream teams are made, not born! Respect the team members and their weaknesses. Team players should think about what the other person will need next. Work hand in hand, not on demand. Try to reach this flow-state of team work.*

14. ALLOCATE ATTENTION WISELY

As our attention is very limited and humans are not good at multi-tasking you need to allocate your attention repeatedly. Two principles might be helpful. First, it is reasonable to develop the rhythms you use for allocating your attention. The ABC-sequence is based on this principle. If you manage to keep to this rhythm you are less likely to miss important details. The second principle is to alternate between focusing on details and focusing on the big picture. Whenever you need to focus on a detail (e.g. a difficult intubation) try to force yourself to go back to the big picture and to re-evaluate your patient's overall status. Try not to get distracted, interrupt long procedures and check the patient.

Remember: You can't concentrate on two tasks at the same time. Make sure you concentrate on the most important information. Situation awareness allows you to distinguish between important and less important information. Allocate your attention actively. Have others check certain aspects for you while you are doing other tasks.

15. SET PRIORITIES DYNAMICALLY

Dynamic situations demand dynamic measures. Don't stick to your "decisions" – they are often based on uncertain and incomplete information. Make (purposeful) preliminary decisions. What was right might be wrong now and vice versa. Having a solution does not mean you have the best solution. However, one priority remains – ensuring stable vital signs at all time. Even if you do not know why your patient is sick, take care of the vital signs and don't get lost in difficult differentials whilst the patient stops breathing.

Remember: After having re-evaluated a situation it might be necessary to define new priorities and goals. Try not to stick to your initial decision - no matter how hard it was to make it. Let your team know your priorities and ask for their view!

HOW CAN CRM-SKILLS BE LEARNED AND TAUGHT?

THEORY

The CRM Key Points mentioned above often seem obvious, maybe even trivial. They are, but using and applying them is not. To improve your CRM-competence you should try to reflect on these principles as close to your working environment as possible. Whenever you have dealt with unexpected events take a few minutes afterwards and try to analyse them by going through the key points. More theoretical background on the principles can be found in the book by Gaba, Howard and Fish [6] as well as in related safety literature [7-16].

PRACTICE

All around the world there is an increasing number of simulation centres [17] in which you can learn the CRM key points hands-on. Combined with theory you work through relevant scenarios in highly realistic environments. During video assisted debriefings you can discuss how the CRM principles can help you to make patients safer. Many of these centres also offer mobile training, meaning that they can bring the simulator and everything needed (e.g. audio-/video equipment) to your facility and train your staff on site. The Society in Europe for Simulation Applied to Medicine SESAM provides links and information [18]

(<http://www.uni-mainz.de/FB/Medizin/Anaesthesie/SESAM/welcome.html>).

HOW CAN CRM-SKILLS CONTRIBUTE TO PATIENT SAFETY?

Although 70% of all errors in medicine are attributable to human factors, there is no formal training to improve that. CRM is not yet a standard part of medical training and there is no clear cut evidence that it improves patient outcome. Large numbers would be needed for such a study. Nevertheless CRM training is an integral and accepted part of training in aviation, nuclear power and other industries in which human errors can lead to catastrophic events. There is no reason to assume that doctors are less error prone or would benefit any less from human factor based CRM training.

In order to improve patient safety CRM key points and their application must be supported by the decision makers and accompanied by organisational improvements. Only if hospitals and other health care organisations provide such a framework can the individual health care worker effectively improve patient safety.

The following citation speaks for itself and makes the message clear:

"...no industry in which human lives depend on the skilled performance of responsible operators has waited for unequivocal proof of the benefits of simulation (or CRM) before embracing it... Neither should anaesthesiology (health care)"[19]

David Gaba, Anesthesiology 76:491-494, 1992

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LINKS

- <http://www.npsf.org/>
- [www.patientsafety.gov \(VA\)](http://www.patientsafety.gov)
- <http://www.jcaho.org/>
- www.npsa.nhs.uk
- <http://anesthesia.stanford.edu/VASimulator>
- [www.medizin.uni-tuebingen.de/psz/english](http://medizin.uni-tuebingen.de/psz/english)

CHECKLIST OPVANG NEONAAT > 32 WEKEN**MATERIAAL op resuscitatiekamer:**

Beademingsmachine (met groene slangen) op trolley	Gebruiksklaar
Caleo (temperatuur 37 graden, vocht 55-60%)	Gebruiksklaar
Monitor: plakkers + thermometer	Gebruiksklaar
Massimo saturatiemeter	Gebruiksklaar
Gaslessen (O2 +perslucht)	Aanwezig en vol
NeoPuff met bijpassend masker	Ingesteld en aan
Uitzuigslang	Gebruiksklaar
Stethoscoop	Aanwezig
Nestje ivt	Aanwezig
Muts	Aanwezig
Intubatiemateriaal (tube, magil, (video) laryngoscoop)	Gebruiksklaar
Fixatiepleisters tube	Gebruiksklaar
Bak nCPAP materiaal	Aanwezig
APGAR-timer	Aanwezig
Navelklem en steriele schaar	Aanwezig
Infuusmateriaal (venflon, plakkers, NaCl)	Aanwezig
Warme doeken	Aanwezig

Materiaal op afdeling (NICU):

Beademingsmachine / CPAP apparaat	Gebruiksklaar
Lijnen materiaal op indicatie	Gebruiksklaar
Infuusmateriaal (venflon, plakkers, NaCl)	Gebruiksklaar

PERSONEEL

Bevoegd neonatoloog	Aanwezig
Bevoegd arts-assistent/physician assistant	Aanwezig
Verpleegkundige neonatologie	Aanwezig
Verpleegkundige obstetrie	Aanwezig
Piepers en telefoons overgedragen/stilgezet	Uitgevoerd

OPVANG neonaat > 32 weken

Thermometer (pasgeborene 36.5 – 37.5 grC)	Check
Pre-ductale saturatiemeter aansluiten + ECG plakkers op indicatie	Check
Opvang ABC door bevoegd arts-assistent / PA/VS onder supervisie van neonatoloog	Check
CPAP op indicatie	Check

Mocht op 1 van bovenstaande items niet het antwoord gegeven kunnen worden dat erachter staat, stop procedure, draag er zorg voor dat dit antwoord wel gegeven kan worden en ga dan verder met de procedure.

Versie 2.0/27-12-2018

Vragen/opmerkingen mbt checklist mailen naar: neonatologie-crm.kg@radboudumc.nl

CHECKLIST OPVANG NEONAAT > 32 WEKEN**NA OPVANG**

NeoPuff en uitzuigapparatuur uitzetten	Gecontroleerd
Debriefing (zoz)	Uitgevoerd
Transport trolley reinigen conform protocol	Gebruiksbaar op gang
Kind opnemen in EPIC(door verpleging) (orderset door arts, zie workflow in Qportaal)	Gecontroleerd

BRIEFING EN DEBRIEFING:

BRIEFING:

1. Introductie: namen, functie
2. Opvang: amenorroedeur, geschat gewicht, eenling/meerling, reden opvang, foetale conditie, voorbereid met Celestone ja/nee
3. Stappen opvang bespreken
4. Taakverdeling (A/B, C, omloop)
5. What if...

DEBRIEFING:

1. Resultaat versus plan
2. Uitvoering:
 - Wat ging goed
 - Wat ging minder
 - Wat doen we de volgende keer anders
3. Samenvatting door de leider

Mocht op 1 van bovenstaande items niet het antwoord gegeven kunnen worden dat erachter staat, stop procedure, draag er zorg voor dat dit antwoord wel gegeven kan worden en ga dan verder met de procedure.

Versie 2.0/27-12-2018

Vragen/opmerkingen mbt checklist mailen naar: neonatologie-crm.kg@radboudumc.nl

Taakverdeling opvang pasgeborene >32 weken**Voor geboorte**

NICU verpl 2	NICU verpl 1	Q10verpl	Zaalarts **	Neonatoloog **
		Check apparatuur		
	Voorbereiden NICU plek	Temp omhoog	Communicatie NICU	
		Briefing	Briefing en taak verdeling	Briefing
		Couveuse warm en vochtig checklist		
		Voorbereiden ouders	Checklist	checklist
		Plastic zak mee naar VK/OK	Voorbereiden opvang	

Geboorte en ondersteuning transitie

		Opvang conform NLS	Opvang conform NLS	Opvang conform NLS
		Geboortetijd	Start apparklok	
		Aangeven baby	Vastleggen geboortetijd	
		Baby afdrogen		
		Dekt baby toe met warme doeken	Hoofd afdrogen Muts op	Hoofd afdrogen Muts op
		SaO2 meter re pols	A en B	A en B
		Assisteren bij ondersteuning A en B	Beoordeling C	Beoordeling C
		NS gassen		Delegeren taken
			Elke 30 sec evaluatie ABC	Elke 30 sec evaluatie ABC
			temp bij vertrek	
		debriefing	debriefing	debriefing
		Opruimen	Langs ouders	Langs ouders
			Belt NICU bij vertrek	

Mocht op 1 van bovenstaande items niet het antwoord gegeven kunnen worden dat erachter staat, stop procedure, draag er zorg voor dat dit antwoord wel gegeven kan worden en ga dan verder met de procedure.

Versie 2.0/27-12-2018

Vragen/opmerkingen mbt checklist mailen naar: neonatologie-crm.kg@radboudumc.nl

Taakverdeling opname pasgeborene >32 weken**<10 minuten na opname NICU**

NICU verpl 2	NICU verpl 1	zaalarts	neonatoloog	Secretariaat
RSVP	RSVP	RSVP	RSVP	Overplaatsen baby naar NICU
Patiënt opnemen NICU	Wegen	Orders in EPIC		Patiënt opnemen NICU
	Vastleggen opname temp			

< 30 minuten na opname NICU

Hulp met installeren	installeren	Infuus prikken*		
Medicatie klaarmaken	Aansluiten infuus*			

< 1 uur na opname NICU

	Vit K < 1 uur		Controle EPIC orders	
	AB < 1 uur *			
	Glucose controle 1 uur*	Glucose controle		

< 2 uur na opname NICU

Omloop	Assisteren bij handelingen aan patient	A&O notitie		
	Assisteren inbrengen lijnen*	Handelingen op indicatie	Handelingen op indicatie	

EINDE GOLDEN HOURS

	Enterale voeding*			

< 6 uur na opname NICU

	Enterale voeding*			

<12 uur na opname NICU

		Korte uitleg ouders		
		LO		

** Taakverdeling hangt hier af van bekwaamheid ass en conditie patiënt

* Indien geïndiceerd

Tijdens kantoor tijden zorgt secretariaat voor opname NICU; daarbuiten NICU verpl 2

Mocht op 1 van bovenstaande items niet het antwoord gegeven kunnen worden dat er achter staat, stop procedure, draag er zorg voor dat dit antwoord wel gegeven kan worden en ga dan verder met de procedure.

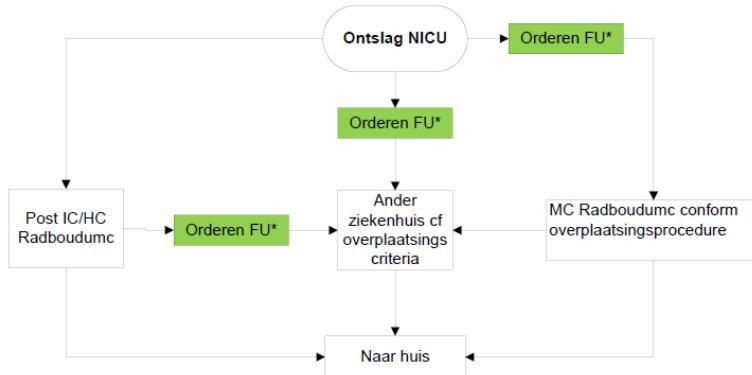
Versie 2.0/27-12-2018

Vragen/opmerkingen mbt checklist mailen naar: neonatologie-crm.kg@radboudumc.nl

Vaste bestanddelen NICU opname na Golden hours

	Crisis anamnese	Icc mij. Werk*	Contact arts benoemen	Zorgteam
	Basis anamnese	Brief wklks	N3 aanbeveling	
	Zorg anamnese	SV wklks		
	Protocollen	ROP aanvragen*		
		Vaccinaties		
		ALGO *		

* indien FOLLOW-UP
geïndiceerd zie
protocol



Mocht op 1 van bovenstaande items niet het antwoord gegeven kunnen worden dat erachter staat, stop procedure, draag er zorg voor dat dit antwoord wel gegeven kan worden en ga dan verder met de procedure.

Versie 2.0/27-12-2018

Vragen/opmerkingen mbt checklist mailen naar: neonatologie-crm.kg@radboudumc.nl

How to turn a team of experts into an expert medical team: guidance from the aviation and military communities

C S Burke, E Salas, K Wilson-Donnelly, H Priest

Qual Saf Health Care 2004;13(Suppl 1):i96-i104. doi: 10.1136/qshc.2004.009829

There is no question that interdisciplinary teams are becoming ubiquitous in healthcare. It is also true that experts do not necessarily combine to make an expert team. However when teams work well they can serve as adaptive systems that allow organisations to mitigate errors within complex domains, thereby increasing safety. The medical community has begun to recognise the importance of teams and as such has begun to implement team training interventions. Over the past 20 years the military and aviation communities have made a large investment in understanding teams and their requisite training requirements. There are many lessons that can be learned from these communities to accelerate the impact of team training within the medical community. Therefore, the purpose of the current paper is to begin to translate some of the lessons learned from the military and aviation communities into practical guidance that can be used by the medical community.

cited above. The cost of any error in teamwork could easily have been life threatening.

Recognising this, as well as the fact that effective teamwork is not automatic, the medical community has begun to implement team training interventions. The most popular of these interventions have been adaptations of crew resource management (CRM) training. While being commended for recognising the importance of teams in error prevention, a recent review of CRM, as applied in the medical community (for example, crisis resource management), revealed that such training has not yet proven to be effective (Wilson-Donnelly *et al.* Does CRM training work? An update, extension, and some critical needs (under review)). Results indicated that, in general, trainees reacted favourably to the training, but the transfer of the learned behaviours to the job or simulated environment was not consistent. In cases where transfer was observed, it was based on a particular simulated scenario² or the experience of trainees.³

The review cited above indicates that although the medical community is making strides in recognising the importance of team training there is still a long road ahead. In this vein, the military and aviation communities have invested a great deal of time, money, and effort over the last few decades to better understand team functioning and training. As a result, there are many lessons that can be extracted and applied to those beginning to implement medical team training with the purpose of increasing the likelihood of effective team training interventions. Therefore, the purpose of this paper is to translate a subset of the lessons learned from the military and aviation communities into practical guidelines. We hope these can serve as guidance to those responsible for designing, implementing, and evaluating medical team training.

On a weekend in a large tertiary care hospital the anaesthesiology team was called to perform anaesthetics for several clinical conditions deemed emergencies. The anaesthesiology team was already overloaded. To make matters more complicated a demanding nurse was insisting that her case be done first, surgeons were complaining that their cases were increasing in urgency, and within the primary operating suites the staff was only able to run two operating rooms simultaneously. The anaesthesiologist in charge was under pressure to attempt to overlap portions of the procedures by starting one case as another was finishing.¹

The above example illustrates not only the dynamic and complex nature of many medical environments, but that the need for teamwork is ubiquitous within this complex environment. The medical personnel described in the above vignette operated primarily as separate individuals rather than a team whose goals were to ensure patient safety and well being. Instead of competing against one another the nurse, surgeons, anaesthesiologists, and operating room staff could have worked together in a coordinated fashion to make decisions regarding patient prioritisation and the best manner in which to deal with a stressful situation given the current constraints. Given the complexity, criticality of conditions, and lack of teamwork the propensity for errors was high in the example

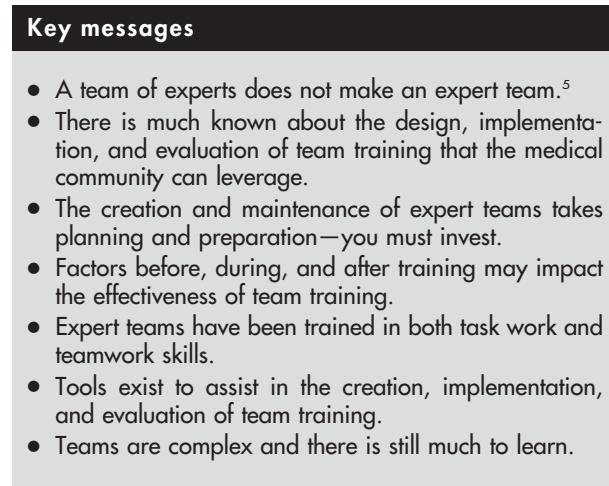
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HOW CAN THE SCIENCE OF TRAINING HELP?

Training can be defined as the systematic acquisition of knowledge (what we think), skills (what we do), and attitudes (what we feel) (KSAs) that lead to improved performance in a particular environment.⁴ The medical community has typically focused on training task work skills, that is, the technical aspects of the job, but as the use of interdisciplinary health care teams increases, training task work skills will no longer

Abbreviations: AO, advance organisers; CRM, crew resource management; KSA, knowledge, skills and attitudes; SA, situation awareness



be sufficient. There is currently over two decades of research evidence coming primarily out of the military and aviation communities which suggests that while task work skills provide the foundation for effective team performance they are a necessary, but not sufficient condition ... teamwork skills are also needed.^{6–9} In this work, task work skills are those skills that members must understand and acquire for individual task performance, while teamwork skills are the cognitive, behavioural, and attitudinal actions that members need to function effectively as part of an interdependent team.¹⁰

Team training provides trainees with the necessary competencies at both the individual and team levels to complete their assigned tasks safely and effectively.¹¹ At the individual level, team members must possess the KSAs needed to perform their specific task roles within the framework of the team. These individual competencies are incorporated into an interdependent, coordinated unit at the team level. In an effort to aid those responsible for developing team training, Salas and colleagues^{12 13} reviewed over 20 years of research and devised a heuristic framework to help conceptualise the basic components of team training (figure 1). This heuristic depicts team training as a set of interventions that are designed and developed with four main elements: a set of tools, delivery methods, instructional strategies, and content.

Tools—for example, team task analysis,¹⁴ feedback strategies, task simulation (Salas *et al.* Improving patient safety through simulation based training: what does it take? (unpublished work))—are used to diagnose, assess, and remediate team performance before, during, and after training. Based on the information gathered through the tools, team training objectives are created and the KSAs needed to complete each objective are identified. This information drives the type of methods used to deliver the training. The three most common methods used to present material to trainees are information based (for example, lecture), demonstration based (for example, behavioural modelling), and guided practice (for example, role play, hands on practice, simulation). These methods come together to create a team training strategy. It should be noted that while there are several team training strategies the medical community has adopted only one—CRM. Table 1 illustrates additional proven strategies.^{12 15}

While figure 1 depicts how tools, methods, and content combine to yield team based instructional strategies, it does not provide direct practical guidance on how to design, implement, and evaluate team training. The next section offers some practical guidance.

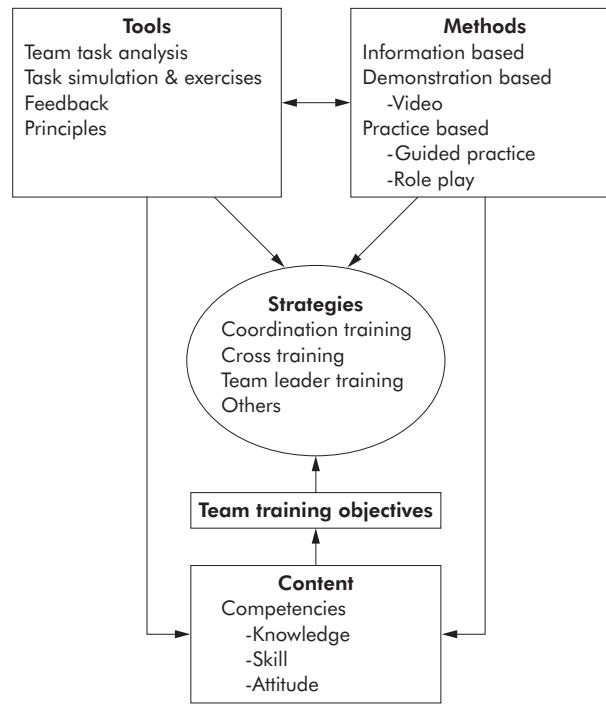


Figure 1 Anatomy of team training.¹³

PRACTICAL GUIDANCE

It has recently been suggested that it is not enough to use a systematic approach to design training, attention also needs to be paid to factors outside the training that may impact its effectiveness.^{26 27} With this in mind, the practical guidance that follows is organised around three themes: (a) setting the stage/pre-team training factors, (b) design/implementation, and (c) post team training factors. The guidelines presented here are those where we have evidence that applying such guidance will lead to a more effective team training programme (table 2).

Setting the stage

Guideline 1: the design and development of team training must be guided by the results of a team task analysis

The foundation of effective team training programmes lies within the a priori determination of the KSAs needed for effective performance on the job in question.²⁸ One of the most common and theoretically grounded methods for determining the requisite KSAs is task analysis. While a variety of methods have been developed for analysing team tasks most do not typically capture the requisite cues, conditions, and standards that provide the basis for team tasks.^{28 29} For example, researchers have found that indices of importance and task criticality used for individual tasks do not translate well for team tasks.³⁰ In light of this need, several researchers have been working over the past decade to develop and refine a procedure known as team task analysis.^{13 30–32} This procedure not only allows researchers and practitioners to identify the operational skills—that is, task work—needed within team tasks, but also identifies the skills needed for smooth coordination among team members—that is, teamwork. Finally, this procedure provides a mechanism by which training objectives can be linked to the KSAs needed to complete the team tasks in question.

The implementation of a team based task analysis is important, for without one, organisations run the risk of only training one of the two skill sets that empirical research has

Table 1 Team instructional strategies

Instructional strategy	Description
Cross training ¹⁶	Team mates develop an understanding for the tasks, duties and responsibilities of coworkers; strategy targets team members interpositional knowledge and shared mental models for development; increases team coordination and reduces process loss
Team coordination training ¹⁷	Also known as CRM; focuses on teaching team members about basic process underlying teamwork; strategy widely applied in aviation, medical, and military communities; targets mutual performance monitoring and back up behaviour
Team self correction training ^{18 19}	Team members are taught techniques for monitoring and then categorising their own behaviours as to the degree of its effectiveness; this process generates instructive feedback so that team members can review performance episodes and correct deficiencies; additional KSAs targeted initiative, communication
Team building ²⁰	Targets role clarification, goal setting, problem solving, or interpersonal relations for improvement. However, recent meta-analytic evidence suggests team building only increases performance when targeting subjective criteria such as role clarification
Assertiveness training ²¹	Utilises behavioural modelling techniques to demonstrate both assertive and non-assertive behaviours; provides multiple practice and feedback opportunities for trainees
Metacognition training ^{† 22}	Targets trainee's executive monitoring and self regulatory cognitive processes for development; training develops metacognitive skills which serve to regulate cognitive abilities such as inductive and deductive reasoning
Stress exposure training ^{23 24}	Targets trainee knowledge of both potential stressors and coping strategies; develops trainee insight into the link between stressors, perceived stress, and individual affect and performance

Table adapted from Salas *et al.*²⁵

*Wilson-Donnelly *et al.*, Does CRM training work? An update, extension, and some critical needs (under review).

† Jentsch F. Metacognitive training for junior team members: solving the "copilot's catch-22." Unpublished doctoral dissertation. Orlando, USA: University of Central Florida, 1997.

CRM, crew resource management ; KSA, knowledge, skills and attitudes.

identified as being required for effective team performance. This state of affairs is evident within the medical community as well as several other communities. For example, a recent review of "team" training programmes within the medical community found that such programmes often teach task work skills without acknowledging teamwork skills (Wilson-Donnelly *et al.*, Does CRM training work? An update, extension, and some critical needs (under review)).

Despite the argued importance of using team based task analysis there remains a lack of prescriptive integrated guidance pertaining to its implementation. In an effort to remedy this state of affairs, researchers¹⁴ extracted a series of steps practitioners can use in conducting a team task analysis (table 3).

As team task analysis is a general technique whose foundation lies within a long history of individual task analysis procedures, it can be applied to a variety of domains and can be readily implemented with minimal modification to the medical community.

Guideline 2: when training time is scarce, pre-practice tools can be used to maximise the impact of training

Recently, it has been argued that a number of factors prior to the actual training and practice session(s) can impact the

utility of practice opportunities during training.¹⁵ As training time is often limited, training developers should not neglect the impact that tools, such as: attentional advice, preparatory information, advance organisers (for example, outlines, diagrams, graphic organisers), and pre-practice briefs may have on maximising practice opportunities. Each of the above pre-practice tools have been argued to maximise practice time, allowing trainees to learn more in shorter amounts of time, by aiding trainees in identifying critical aspects of training. Attentional advice directs trainee attention towards particular factors in the practice environment thereby improving the utility of practice.^{34 35} For example, in teaching medical teams how to assess and perform initial treatment on trauma alert cases attentional advice may be given prior to using a simulation in terms of those aspects that are the most difficult or important.

Preparatory information serves a similar function in that it can be used prior to practice to set trainee expectations about the events likely to occur and their consequences. The use of information of this type has effectively been used within the medical community to reduce anxiety and reactions to stress and is now extending to other domains.^{23 24} Although the exact content contained within preparatory information may differ according to domain, it tends to focus on an explanation of the physiological reactions that are likely to

Table 2 Guidelines for effective team training

Themes	Description
Setting the stage	
Guideline 1	The design and development of team training must be guided by the results of a team task analysis.
Guideline 2	When training time is scarce, pre-practice tools can be used to maximise the impact of training.
Guideline 3	Ensure latent organisational messages about the importance of team training match those that are spoken.
Design/implementation	
Guideline 4	Team training must emphasise key teamwork components.
Guideline 5	Design team training to facilitate shared understanding among team members.
Guideline 6	Ensure team training facilitates adaptive behaviours.
Guideline 7	Team training must promote attitudes and behaviours that are indicative of a learning climate.
Guideline 8	Ensure team members apply closed loop communication.
Guideline 9	Design team training to create systematic opportunities for practice of requisite team competencies.
Post training	
Guideline 10	Evaluate team training and collect a variety of evidence as its impact.

Table 3 Guidance for conducting team task analysis

Steps	Tasks
(1) Conduct a requirements analysis	Define target job by creating a narrative describing the duties and conditions under which the job is to be performed Identify knowledge elicitation procedures to be used to gather information during team task analysis (see Burke ¹⁴) Develop protocol for conducting task analysis Identify subject matter experts; number and type dependent on stage of analysis and resources
(2) Identify tasks that comprise target job	Review source documents and conduct interviews with SMEs to identify full range of tasks conducted on job Write task statements for each task; statement should: (a) be direct and avoid long sentences, (b) begin with a verb that describes the type of work to be accomplished, and (c) describe what the worker does, how it is done, to whom it is done, and why it is done. ³³
(3) Identify teamwork taxonomy	Define what you mean by teamwork by selecting a taxonomy; will serve as foundation for coordination analysis which determines which tasks related to task work and teamwork, respectively
(4) Conduct coordination analysis	Choose method; most common are surveys; use team taxonomy identified in step (3) as a framework to ask SMEs the extent to which each of the a priori identified tasks require each teamwork behaviours (as seen in taxonomy), as well as an overall assessment of teamwork. Subject information to techniques such as cluster analysis to identify task clusters based on coordination demand. Ensure SMEs during this phase are comprised of job incumbents and/or supervisors
(5) Determine relevant teamwork and task work tasks	Take list of tasks, both task work and teamwork, gathered to this point and determine which tasks are most relevant; to gather this information questionnaires are typically given to SMEs who perform the job. On the left hand side of this questionnaire would be the tasks that have been identified as comprising the job. Each task is then rated according to the indices chosen (task work—importance to train, task frequency, task difficulty, difficulty of learning, importance to job) (teamwork—task importance was best predicted by a composite measure that included task criticality augmented with ratings of importance to train). ²¹

Table adapted from Burke.¹⁴
SME, subject matter expert.

occur regarding the stressful event. Preparatory information typically addresses how the person is likely to feel, describes the events that are likely to occur, and how to mitigate these undesirable consequences.²³

Advance organisers (AO) are another pre-practice tool that helps trainees develop a basic structure—that is, their expectations—for the information that is to be provided during training. This, in turn, aids in the internalisation of information learned, easing the integration of new knowledge with existing knowledge. Advanced organisers come in many forms and researchers have offered guidance in terms of the steps required to develop these tools. Steps include:

- (1) inform trainees of advance organiser purpose,
- (2) identify topics of tasks,
- (3) provide organising framework,
- (4) clarify action to be taken,
- (5) provide background information,
- (6) state concepts to be learned,
- (7) clarify concepts,
- (8) introduce vocabulary, and
- (9) state the general outcome/goal desired.³⁶

Advanced organisers within the medical community have been shown to be effective³⁷ and may come in the form of course outlines or graphical/pictorial diagrams handed out prior to training which illustrate key components to be included in training. In keeping with the earlier trauma example, an AO might be a graphical representation related to the cascading symptoms which indicate such a call.

In addition to assisting individual performance in training these AOs have also been argued to facilitate team training in that they provide a foundation for the shared knowledge that drives teamwork and the requisite coordination requirements. For example, pre-practice briefs can be used prior to training to clarify team performance expectations and set

team member roles and responsibilities prior to practice. In turn, this serves to develop shared knowledge and increase coordination. Such briefs are commonly used within the aviation, military, and medical communities, but often not in a training environment.^{38 39}

Guideline 3: ensure latent organisational messages about the importance of team training match those that are spoken

Organisations spend up to \$100 billion on training and development, but less than 10% of these expenditures actually result in a positive training experience where skills are transferred back on the job.⁴⁰ Research has shown that characteristics of the work environment such as supervisor and peer support and opportunities to practice skills back on the job impact the effectiveness of training.^{41–43} Messages sent by the organisation and supervisor regarding the importance of training have an impact. For example, research indicates that leaders can significantly influence the effectiveness of training (that is, the likelihood of transfer back to job) simply through informal reinforcement of trained behaviours.³² Research has shown that teams containing a leader that was perceived as being supportive exhibited 42–52% more behaviours consistent with the trained skill than those with non-supportive leaders.⁴³

In addition, how the organisation frames the training experience in terms of attendance policies, where training is placed (within the broader curriculum), and how behaviour learned in training is promoted back on the job all speak to the organisation's view of training's importance. For example, evidence indicates that when training is framed as remedial it reduces trainee motivation and learning; while framing it as advanced contributes positively to motivation and learning.^{44 45} In addition, attendance policies (that is, voluntary v mandatory) are also believed to influence the outcomes of training such that the outcome is better when attendance is framed as voluntary.⁴⁶

Design/implementation

Guideline 4: team training must emphasise key teamwork components

The past 20 years has witnessed many advances in what is known about teamwork.⁴⁷ As a result many models have been developed that not only illustrate the dynamic and multi-dimensional nature of teamwork, but also show the importance of process variables in determining team performance.⁴⁷⁻⁴⁸ Recently researchers⁴⁹ reviewed the team literature and argued that at its simplest teamwork consists of a set of five competencies—adaptability, leadership, back up behaviour, mutual performance monitoring, and team orientation (table 4)—which are bound together through communication processes that result in shared mental models pertaining to the task, team, and situation. While the above constructs provide a generalisable set of teamwork competencies which have clearly shown their importance through empirical work (Wilson-Donnelly *et al.* Does CRM training work? An update, extension, and some critical needs (under review)),¹⁰⁻¹⁵ there may be other competencies that are additionally relevant dependent on the domain. Note that while the competencies cited below serve as an initial starting point, a team task analysis (see guideline 1) should be conducted to ensure the competencies most relevant for the job/task being trained are identified.

Guideline 5: design team training to facilitate shared understanding among team members

When operating within complex and dynamic domains (for example, the medical arena), stressors such as time pressure, fatigue, and workload tend to narrow attention increasing the possibility of errors. Due to cognitive limitations it is not possible for one person to process all the relevant information. Through the promotion of shared cognition in which all members are continually monitoring, assessing, and communicating key environmental cues, performance is facilitated.

Three factors which contribute to this state are: shared mental models, situational awareness (SA), and metacognition. Shared mental models describe the degree to which long term memory structures held by team members regarding aspects of the task and team are aligned such that substantial agreement exists.⁵⁵ This shared knowledge serves to guide coordinated action and allows members to quickly determine when something is “out of place”. For example, in deciding whether a trauma alert call should be placed to the hospital team, members of the emergency medical services first response team whom have a shared conceptualisation of each other’s roles can maximise the timeliness and quality of the call through better coordination and decision making. When team members have this shared knowledge it also provides them with the foundation and ability to offload the work of members whom are overloaded. Recently a wealth of empirical evidence is beginning to emerge to support the theoretical arguments concerning the importance of shared mental models to team performance (Burke CS. *Examination of the cognitive mechanisms through which team leaders promote effective team processes and adaptive team performance*. Unpublished doctoral dissertation. Virginia, USA: George Mason University, 1999).¹⁶⁻⁵⁶⁻⁵⁸ Furthermore many of the training strategies shown in table 1 have been shown to facilitate the development of shared mental models as can many of the pre-practice tools identified earlier.

Situation awareness refers to the “perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status into the near future” (Endsley, p. 36).⁵⁹ It’s the result of members scanning of the environment and the perceiving of cues and patterns in a dynamic context. Information gained is then communicated and integrated into existing knowledge structures serving to update members’ shared mental models.⁶⁰ Empirical work, conducted primarily with “real teams” within the military and aviation communities, has consistently found that effective teams hold higher levels

Table 4 The “big five” of teamwork³⁸

Teamwork competencies	Definition	Behavioural examples
Team leadership ^{26 50 51}	Ability to direct and coordinate the activities of other team members, assess team performance, assign tasks, develop team KSA’s, motivate team members, plan and organise, and establish a positive atmosphere.	Facilitate team problem solving Provide performance expectations and acceptable interaction patterns Synchronise and combine individual team member contributions Seek and evaluate information that impacts team functioning Clarify team member roles Engage in preparatory meetings and feedback sessions with the team
Mutual performance monitoring ⁶	Ability to develop common understandings of the team environment and apply appropriate task strategies in order to accurately monitor team mate performance.	Identifying mistakes and lapses in other team members actions Providing feedback regarding team member actions in order to facilitate self correction
Backup behaviour ⁵²	Ability to anticipate other team members’ needs through accurate knowledge about their responsibilities. Includes the ability to shift workload among members to achieve balance during high periods of workload or pressure.	Recognition by potential back up providers that there is a workload distribution problem in their team Shifting of work responsibilities to underutilised team members Completion of the whole task or parts of tasks by other team members
Adaptability/flexibility ^{50 53}	Ability to adjust strategies based on information gathered from the environment through the use of compensatory behaviour and reallocation of intrateam resources; altering a course of action or team repertoire in response to changing conditions (internal or external).	Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with the changes Identify opportunities for improvement and innovation for habitual or routine practices Remain vigilant to changes in the internal and external environment of the team
Team/collective orientation ⁵⁴	Propensity to take others’ behaviour into account during group interaction and the belief in the importance of team goal’s over individual member’s goals.	Taking into account alternative solutions provided by team mates and appraising that input to determine what is most correct Increased task involvement, information sharing, strategising, and participatory goal setting

of SA than low performing teams.^{61–64} Within our trauma alert example, team members would need to be aware of key components of the situation which might impact the interpretation of patient symptoms. Within a team setting this information/assessment needs to be shared so everyone is operating from a similar picture in making the decision as to call an alert or not.

In term of developing SA the most common tack that has been taken is to design systems such that SA is facilitated. However, recently researchers have begun to develop and implement training programmes which assist in the development and maintenance of SA. Research on pilots has indicated several target areas which may improve pilot SA, these are: task management, development of comprehension, projection and planning, information seeking, and self checking activities.⁶⁵ Working with this same population, researchers have begun to define basic training approaches, including: higher order cognitive skills training, intensive pre-flight briefings, schema and mental model development, and structured feedback.⁶⁶ Cue recognition training is another method which has successfully been used to facilitate the development of SA.⁶⁰ It is expected that while these approaches would apply to the medical community they might need to be modified due to the structure of teams within medicine as well as the level of distraction.

Simultaneous to this assessment process is the requirement to regulate one's own monitoring and interpretation of input by engaging in metacognitive processes. Metacognitive processes allow the learners to gain awareness of the current state of knowledge and the effectiveness of their learning strategies. Within the trauma case metacognitive activities might serve to alert a member performing a complex procedure that he/she is doing something slightly off, perhaps due to the stress, and allow that person to revise the procedure without being corrected by a fellow team member. Metacognitive processes also allow active mental models to be modified such that they provide a context sensitive assessment of the current situation. Within the team, this assessment needs to be shared not only to promote a common awareness of the situation, but it also mitigates the impact of an individual's attention narrowing. While evidence has clearly shown the importance of metacognitive processes to individual performance its application to teams is a fairly recent development with their being few explicit strategies used at the team level to train these processes.

Guideline 6: ensure team training facilitates adaptive behaviours

The propensity to be adaptive is one of the hallmarks of an effective team and the factor which serves to allow teams to perform as more than the sum of their parts. Within the health care community there are a preponderance of redundant systems in terms of machines, however fellow team members can also be thought of as redundant systems. Teamwork encourages resilience to errors in that members may serve as adaptive systems by providing back up and monitoring behaviours. Empirical evidence has shown they can reallocate resources and recombine strategies as they perform.¹⁵ Back up behaviours and monitoring provide teams with an effective means to manage errors that occur by avoiding, trapping, or mitigating the consequences of errors.⁶⁷ In order to manage errors within teams one of three things must happen: (a) team members ask for help when overloaded, (b) team members monitor each others performance to notice any performance decreases (mutual performance monitoring), or (c) team members take an active role in assisting other team members who are in need of help (backup behaviour). An essential component to the above actions happening is trust among team members.

While breakdowns in monitoring and backup behaviour have been implicated in several accidents involving aviation,⁶⁸ these behaviours have also been implicated in near misses within the medical community. For example, a recent report indicated that while many operating room teams are required to conduct a "count" procedure of the tools that have been used during surgery, items such as the tissue retrieval bag are not included in this count. Within the above report, a nurse indicated that recently a tissue retrieval bag was almost left in a patient's wound, but luckily a team member noticed the bag before the procedure was completed. This example illustrates monitoring in that someone noticed the bag was left in and backup behaviour in that the person spoke up so that it was taken out prior to closing.

In addition to the above behaviours shared mental models serve as the foundation for a team's ability to be adaptive in the sense that these cognitive structures contain the information needed for team members to be able to identify when things are "out of place" as well as how members may be supported. Therefore, one way to facilitate adaptive team behaviours is to ensure the possession of shared mental models. In addition to this there are other design features which can be built into team training to facilitate the team's adaptive capacity. For example, based on work conducted on transfer of training, it is known that training which presents multiple examples of varying complexity and situations serves to broaden and deepen trainee cognitive structures. Varying the nature of examples and practice opportunities serves to provide trainees with a broader response repertoire that can be pulled from, thereby increasing the potential for adaptability. This type of intervention should be fairly easy for any community to work into training in the design phase, especially if training is simulation based (see below).

Guideline 7: team training must promote attitudes and behaviours that are indicative of a learning climate

Within environments where errors are relatively infrequent, but high cost, team members must treat every potential opportunity as a learning event. In order to promote this type of "learning climate" team members must not only be willing to speak up, but must also trust that what they say or do will not be held against them. While actions such as mutual performance monitoring can be used as feedback for learning, it does no good if team members cross check and monitor one another's actions if when something out of the ordinary is recognised no one speaks up due to fear of reprimand. The ability to speak up in a non-threatening and respectful manner (deference to expertise) is a hallmark of learning organisations and the teams within them.

Assertiveness training is one mechanism that can foster the propensity for junior team members to speak up when a concern exists. Assertiveness training involves teaching individuals to clearly and directly communicate their concerns, ideas, feelings, and needs to others.²¹ Assertiveness is trained not only so that junior members feel comfortable offering their perceptions to higher status members, but also so that communication is delivered in a manner that does not demean others or infringe upon their rights. In turn, this allows teams to take full advantage of the potential synergy available within the team by deferring to expertise in any given situation, regardless of rank. A recent review of CRM within both commercial and military environments has shown that promoting assertiveness has been a challenge for these communities (Wilson-Donnelly KA, Salas E, Burke CS. *Crew resource management training in the military and beyond: a review and lessons learned*. (Unpublished working document)). Given the similarities to aviation, in terms of power differences within teams, we would predict

this to be a potential roadblock to effective team performance within the medical community. The reader is referred to the references in table 1 for more information on how to train this skill.

Guideline 8: ensure team members apply closed loop communication

Researchers⁶⁹ have argued that communication breakdowns are the second most frequently cited cause of teamwork failures and accidents. In order to combat this the military has taught their teams and crews a particular type of communication strategy—closed looped communication.^{6 70} It is expected that this communication strategy will be especially important for teamwork within the medical community as many of the teams are interdisciplinary. While interdisciplinary (for example, nurse, surgeon, anaesthesiologist) teams are often necessary in complex environments the propensity for miscommunication increases in these teams as each discipline has their own “jargon”. Closed loop communication is one strategy that has been successfully implemented within the military to aid in the above situation. Closed looped communication is built upon a strategy of verification that ensures that the message sent was received and interpreted as intended. Specifically, closed loop communication involves (1) the sender initiating a message, (2) the receiver receiving the message, interpreting it, and acknowledging its receipt, and (3) the sender following up to insure the intended message was received.⁶ An example of the use of this strategy within the trauma call might be witnessed on the actual call from the field to the hospital. The field unit may report that they have a trauma patient with injury of type x and vitals of type y. The person receiving the message on the other end of the transmission would acknowledge the transmission and then repeat or read back the key information that should have been extracted. Finally, the field unit responds with an acknowledgment, unless there is something missing from transmission.

Closed loop communication is often trained or promoted through the use of standardised terminology and procedural type communication. This is combined with an agreement or norm that when possible communication transmission will follow the three step sequence laid out above.

Guideline 9: design team training to create systematic opportunities for practice of requisite team competencies

Everyone has heard the adage, “practice makes perfect”.⁷¹ While it is known that practice is needed to acquire new skills, it is often falsely believed that task exposure alone will lead to learning new behaviours. Task exposure, while beneficial, does not equal learning. Practice needs to be guided and requires measurement and feedback.⁷² By guiding practice and ensuring that participants practice targeted behaviours and attitudes not only is training time maximised, but trainees develop appropriate mental representations of the task⁷³ (as opposed to inaccurate knowledge structures that are difficult to correct once formed).

Within the aviation and military communities there are primarily two types of guided practice that have been used successfully and would be expected to transfer to the medical community: *a priori* scripted scenarios and role plays. *A priori* defined scenarios have provided a foundation for much of the training work done within the military.^{74 75} In using a scenario based approach to practice, subject matter experts help in creating scenarios that contain embedded cues/triggers. These cues, based on training objectives, represent structured opportunities for team members to practice the competencies targeted in training. Using this method of practice not only ensures that opportunities to practice

targeted behaviours are present, but also eases observation as observers have an idea of when key events should occur (for more detail see Salas E, *et al*. Improving patient safety through simulation-based training: what does it take? (unpublished)).

Role plays are another method which has been used to provide guided practice within the aviation community.⁷⁶ While varying in the degree to which they are structured, role plays generally proceed as follows. Participants are given a description of a scenario and their role in it. In most cases they are told to assume they are in the scripted scenario and should respond to both the situation and the actions of other players. Upon completion guided discussion revolving around key learning points occurs. Role plays are a common technique used across a wide variety of training environments and have proven to be successful provided they are structured according to learning objectives and include guided discussion. Within the medical community the use of standardised patients and objective structured clinical exams for medical students is an example of a role play which could be structured according to learning objectives (for example, teamwork skills, clinical diagnosis).

Post training guidance

Guideline 10: evaluate team training and collect a variety of evidence as its impact

Training evaluation has been defined as “the systematic collection of descriptive and judgmental information necessary to make effective training decisions related to the selection, adoption, value, and modification of various instructional activities” (Goldstein, p. 147).²⁸ Evaluation provides insight into whether the content and methods utilised in training were appropriate, how to maximise transfer, and may serve as the content of feedback delivery for programme participants. The bottom line is that without systematic evaluation the organisation will not know if the money spent on training is worthwhile or if it is training the correct skills effectively, which in turn may open organisations to litigation.

While very important systematic evaluation of training within a real world context (outside the laboratory) is not easy for the following reasons: (a) often not a well defined measurable, “ultimate” criterion, (b) resource intensive, (c) organisations want to see return on investment (ROI) and this requires a longitudinal approach, and (d) many don’t know how to make a case for systematic evaluation. Given these constraints and the absence of an ultimate criterion it becomes important to assess training at multiple levels. In this vein, Kirkpatrick argued for a multi-level approach to training evaluation consisting of four levels of evaluation: (1) reactions (utility, affective), (2) learning, (3) behaviour (that is, extent of performance change), and (4) results (that is, degree of impact on organisational effectiveness or mission success). Within recent years, this typology has been expanded by several researchers.⁷⁷ For example, researchers have argued that learning is multi-dimensional and results in cognitive, affective, and skill based learning outcomes.⁷⁷ In addition, collecting data at multiple levels is important not only in that each additional source of data serves to increase confidence in the overall evaluation,⁷⁸ but because there is not an automatic link between the levels. For example, although reaction data can indicate whether the trainee felt the programme was worthwhile, it has little if any relation to whether the participant learned the material. Similarly, just because a trainee learned the knowledge during training does not guarantee that he/she can translate this knowledge into effective behaviour, nor does it guarantee that, if applied, the behaviour will have an effect on organisational outcomes.

The importance of systematic evaluation efforts can be seen within the aviation community and its application of CRM training, which has been touted as a success anecdotally. A recent review of published CRM training studies indicated that while CRM is generally effective in producing some level of change in participants (for example, reaction, learning, behaviour), a lack of multi-level evaluation efforts makes it difficult to answer whether CRM is truly effective.¹⁷ For further examples of how information is gathered on each of these levels the reader is referred to work by Salas and colleagues.¹⁷

APPLYING THE GUIDANCE

Throughout this paper we have provided a series of theoretically based and empirically validated guidelines that can assist the medical community in transforming teams of experts into expert teams. Couched within many of the guidelines are tools which can assist practitioners in their implementation. While the presented guidelines represent a start they only touch the tip of the iceberg in terms of what is known about the creation and maintenance of effective teams. Much of what has been presented is based on evidence culminating from the aviation and military communities and their large investment in teams over the last 20 years. If there is one lesson that the medical community needs to learn from those who have come before, it is that the creation and maintenance of effective teams takes time and effort. In order for organisations to capitalise on the synergy present within teams they must INVEST. The guidelines presented within this paper are only the first step.

CONCLUSION

Within dynamic and complex environments—for example, the medical community—teams can be used as an intervention by which to promote safety and reduce errors. However, if not properly trained in the requisite teamwork competencies teams can actually become a liability to the organisation. The medical community has begun to recognise this fact and has turned to the military and aviation communities to look for interventions that could be adapted for use within a medical domain. This has resulted in the medical community beginning to implement a form of CRM training. However while adopting team interventions from communities with more experience there has been a lack of practical guidance for those in the medical community pertaining to the development, implementation, and evaluation of such programmes. It is our hope that this article serves as an initial step in providing that guidance along with promoting awareness within the medical community that CRM training is only one of many team training interventions.

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Building a culture of safety through team training and engagement

Lily Thomas, Catherine Galla

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ABSTRACT

Medical errors continue to occur despite multiple strategies devised for their prevention. Although many safety initiatives lead to improvement, they are often short lived and unsustainable. Our goal was to build a culture of patient safety within a structure that optimised teamwork and ongoing engagement of the healthcare team. Teamwork impacts the effectiveness of care, patient safety and clinical outcomes, and team training has been identified as a strategy for enhancing teamwork, reducing medical errors and building a culture of safety in healthcare. Therefore, we implemented Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS), an evidence-based framework which was used for team training to create transformational and/or incremental changes; facilitating transformation of organisational culture, or solving specific problems. To date, TeamSTEPPS (TS) has been implemented in 14 hospitals, two Long Term Care Facilities, and outpatient areas across the North Shore LIJ Health System. 32 150 members of the healthcare team have been trained. TeamSTEPPS was piloted at a community hospital within the framework of the health system's organisational care delivery model, the Collaborative Care Model to facilitate sustainment. AHRQ's Hospital Survey on Patient Safety Culture, (HSOPSC), was administered before and after implementation of TeamSTEPPS, comparing the perception of patient safety by the healthcare team. Pilot hospital results of HSOPSC show significant improvement from 2007 (pre-TeamSTEPPS) to 2010. System-wide results of HSOPSC show similar trends to those seen in the pilot hospital. Valuable lessons for organisational success from the pilot hospital enabled rapid spread of TeamSTEPPS across the rest of the health system.

INTRODUCTION

Numerous strategies exist to address the global issue of patient safety; however, the ongoing occurrence of adverse events in healthcare calls for adaptable and sustainable strategies that address the challenge at many levels.^{1–3} Organisational leaders continue to create solutions, expend time and effort to implement them, yet find improvements to be unsustainable. Staff faced with competing priorities and incessant innovations often regard new strategies as another flavour of the month.

BACKGROUND

Seeking to optimise the effectiveness and sustainability of safety initiatives, our health system leadership concluded that transforming to a culture of safety was the prerequisite to attain our patient safety goals. The vision was to build a sustainable culture of safety as the foundation for our

organisation to guide daily practice creating a zero tolerance for errors, and empowerment to speak up and influence actions to facilitate safety.

The impact of organisational cultures is documented; it drives behaviour and influences performance outcomes.⁴ Our experiences also validate that 'the challenge of patient safety is not only clinical, but also organisational',⁵ and justified the solution to build a culture of safety.

Creating a culture of safety in healthcare organisations requires the participation of all members, as healthcare delivery requires multiple caregivers to work together as an effective team with the goal of achieving desired patient outcomes and preventing harm. The quality of teamwork impacts the effectiveness of care, patient safety and clinical outcomes.⁶ Poor teamwork is cited as a major factor in adverse events,⁷ however, effective teamwork requires training and development, and formal training is recommended.^{6–8} Team training has been identified as a strategy for enhancing teamwork,⁹ reducing medical errors and building a culture of safety in healthcare.¹⁰

The problem

Our experience mirrored the current healthcare landscape. As a health system, we invest heavily in quality improvement which includes ongoing monitoring of patient outcomes and developing process improvement as needed. Despite numerous patient safety processes, preventable adverse events continued to occur; improvements were often short term and not sustained to our expectations.

Setting

The North Shore LIJ Health System (NSLIJHS) is comprised of 15 hospitals, two skilled nursing facilities, an institute of medical research and a medical school. It is the nation's second largest, non-profit, secular healthcare system, based on the number of beds, the nation's 18th largest healthcare network, based on net patient revenue, and the largest in New York State.

STRATEGIES FOR IMPROVEMENT

Choice of solution

We selected Team Strategies and Tools to Enhance Performance and Patient Safety, (TeamSTEPPS), an evidence-based framework developed by the Agency of Healthcare Research and Quality (AHRQ), and Department of Defense as the intervention for organisational transformation to a culture of safety. This report will describe the use of TeamSTEPPS for team training, coupled with establishment of an infrastructure for ongoing team

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engagement and sustainment for building a culture of safety across a multihospital health system.

Rationale for choosing TeamSTEPPS for team training and engagement

TeamSTEPPS addresses leading causes of medical errors, and improves quality, safety and efficiency in healthcare. It is specifically designed as a resource for healthcare providers to improve patient safety through effective communication and teamwork skills.¹¹ Its implementation is based on Kotter's Principles of Change.¹² The framework is supported by over 20 years of research, and was field tested in tertiary and community, as well as civilian and army hospitals increasing its applicability across varied settings.¹³

This versatility fits the vision and need of our health system, as it can be adapted according to the needs of the organisation; to create transformational change (culture change) or incremental change (continuous improvement/problem solving).

All members of the healthcare team with direct or indirect involvement in care of patients need to be trained in teamwork.⁸ TeamSTEPPS curriculum,⁶ targets clinical and non-clinical members of the healthcare team leading to effective partnerships across the organisation. The profound simplicity of TeamSTEPPS increases its applicability.

TeamSTEPPS is comprised of five core principles; Team Structure, Leadership, Situation Monitoring, Mutual Support and Communication.¹⁴ Within these principles a variety of skills, competencies and checklists are clearly articulated and developed to translate the concepts into practice. The core principles lead to changes in knowledge, skills and attitude of the team members, demonstrated by a shared mental model, mutual trust and team orientation. Further, the availability of a training delivery system with a multimedia toolkit and a standardised curriculum with implementation guidelines provided free or at nominal costs by AHRQ, enhanced our choice.

TeamSTEPPS provides the organisational processes to optimise clinical interventions. For instance, an infrastructure is provided to support staff involvement and involving staff early in the change process (rather than imposing the change on them) is essential for success.¹⁵ Proactive error prevention warrants the redesign of the current system to foster organisational processes like teamwork, communication, accountability, shared decision making and problem solving to augment clinical strategies for high-quality care delivery.¹⁶

Implementation

The health system became early adopters of TeamSTEPPS; implementation began in the pilot hospital in September 2007 and was completed in 2008. In 2008, senior leadership decided to implement TeamSTEPPS system-wide and allocated resources. A corporate-level team with expertise in research and Evidence-Based Practice (EBP), education and process improvement was formed to lead the TeamSTEPPS implementation.

Communicating the vision

Aligning team-training objectives and safety aims with the organisational goals is recommended for creating successful training programmes.¹⁷ Our goal was to communicate the relevance of TeamSTEPPS to the organisational vision and mission, thus building a foundation for sustainment at every phase of implementation. By discussing the organisational care model (figure 1) at the beginning of every TeamSTEPPS class, and highlighting the TeamSTEPPS framework as a supporting

process within that model in pursuit of our core value of safety, we communicated the relevance and permanence of the change.

Within our organisational model, the Collaborative Care Model, safety is one of the core values. Donabedian's model of Structure+Process=Outcomes, supports the model's applicability and utility.¹⁸ In this model, structure refers to our practice environment, encompassing both the tangible physical environment and the intangible—the culture. Process refers to our care delivery framework, within which we embed various processes, as needed. TeamSTEPPS was introduced as a process to operationalise the core value of safety. Highlighting the model served to emphasise our philosophy and core values, even though our structures, processes or methods may change.

Creating an infrastructure for implementation and ongoing team engagement

TeamSTEPPS curriculum provides an infrastructure for implementation that includes leadership at the executive level as well as interdisciplinary front-line staff identified within the infrastructure as the Change Team.

The Change Team is described as a multidisciplinary team of leaders and staff with the expertise, credibility and motivation necessary to drive a successful TeamSTEPPS implementation.¹⁴ We customised the council-based infrastructure of our organisational care model, Collaborative Care Councils, to function as change teams at the unit/department level. These interdisciplinary teams of frontline staff are not disbanded and, thus, support the message of permanence, enabling ongoing team engagement and anchoring of initiatives. Further, the councils provide a forum for front-line teams to provide input and make decisions, increasing their accountability and empowerment.

The pilot

One of the community hospitals volunteered to be the pilot site for TeamSTEPPS. This acute care facility has 239 beds and 1300 employees. The corporate team partnered with the executive leadership of the pilot hospital to plan for TeamSTEPPS implementation using the programme's three-phase design: (1) assessment; (2) planning, training and implementation and (3) sustainment.¹⁴

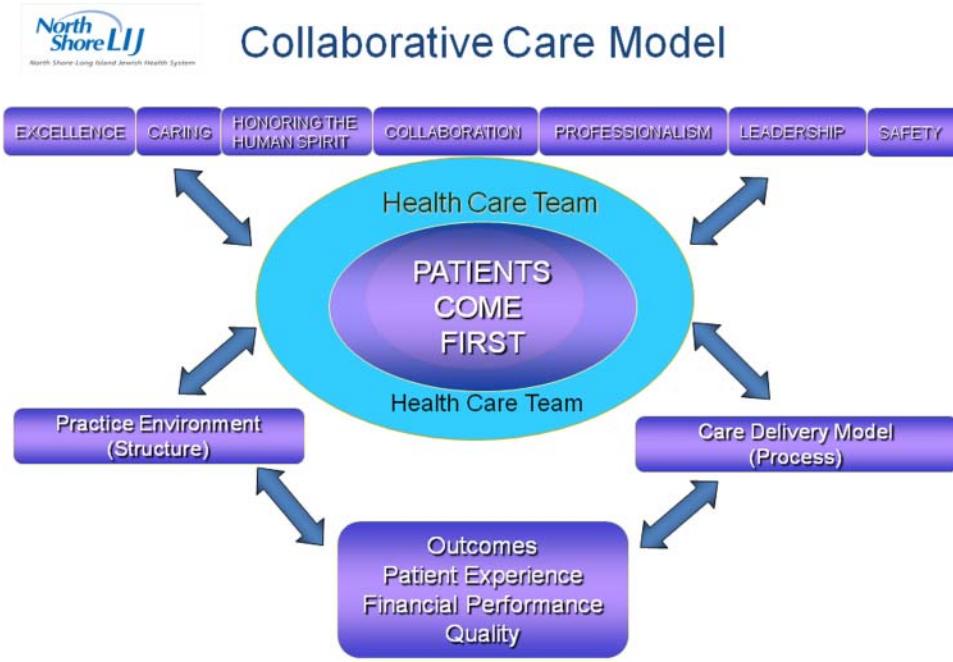
Phase I: assessment—setting the stage

The goal of Phase 1 was to determine the organisation's readiness to implement TeamSTEPPS and was exemplified by the leadership's commitment to change and willingness to allocate necessary resources.¹⁴ An overview of TeamSTEPPS was provided to the hospitals' executive leadership, followed by in-depth discussion and planning.

Hospital leadership chose to adopt TeamSTEPPS for creation of transformational as well as incremental change. The AHRQ tool, Hospital Survey on Patient Safety Culture, (HSOPSC), was utilised to carry out an assessment of the staff perception of the culture of safety in the organisation, and served as a baseline for future measurement of transformational change post-TeamSTEPPS implementation.¹⁹ Incremental changes were to be assessed by the unit-based teams using selected preinterventional and postinterventional measures depicting the change.

Phase II: planning, training, and implementation

Phase II involved creating an action plan, conducting staff training and testing and implementation of TeamSTEPPS. The action plan addressed the goals and method of TeamSTEPPS implementation, the desired outcomes and means of measuring the outcomes.



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Figure 1 The organisational care model. This figure is only reproduced in colour in the online version.

Training

Plans were made to educate the entire hospital in TeamSTEPPS skills. The standardised curriculum included the following: (1) a 2.5-day Master Trainer course for preparing those who would train TeamSTEPPS coaches and trainers; (2) a 4 hour TeamSTEPPS Fundamentals course for staff providing direct patient care and (3) a TeamSTEPPS Essentials course to all non-clinical staff. We adopted a unique approach to Master Training, and required all formal leaders to be trained in preparation for functioning as TeamSTEPPS coaches. This aligned both with our desire to rapidly implement and to embed the skills by preparing leadership to coach and support staff. Staff were released in cohorts according to the sequence of implementation. Classes used facilitation versus a pure didactic approach; facilitation involves coordinating interactions which leads to changes in mindset.²⁰ This meant setting the stage for open, respectful and honest dialogue. Questions and concerns were addressed, discussions proved useful in lending clarity and allaying anxiety. Physician Master Trainers were used to train voluntary physician groups, and attending physicians. Physician participation was essential to lend credibility and maintain engagement of the multidisciplinary teams.

The sequence for TeamSTEPPS implementation identified in Phase 1 was used to plan the training. The goal was to train staff in cohorts representing their work teams, with a short time lag between training and adoption of TeamSTEPPS core skills in practice. To accomplish this, a large number of classes were offered in a short time span. We offered courses twice a day, and during weekend and evening hours to accommodate staff schedules.

Responses from leadership and staff were positive. Although there was consensus that TeamSTEPPS was a great programme, questions remained on how the concepts would translate to practice and whether it would be successful. There was concurrence on wanting this new reality of a transformed culture; however, the prevailing attitude was one of believing in TeamSTEPPS

utility only when the desired changes in environment were observed; emotions ranged from excitement to scepticism.

Testing adoption: unit-based pilot

TeamSTEPPS implementation was done in a pilot unit prior to spreading it in the entire organisation. The unit's council was asked to develop recommendations for translating the TeamSTEPPS tools and strategies (table 1) into practice, and a timeline was created as a guide for facilitating a rapid, systematic and structured transition.

The first set of tools, Briefs, Huddles and Debriefs, was selected for their relative ease of implementation, as well as likelihood of enhancing team cohesion. The unit council planned for implementing the selected tools by determining the necessary logistics of timing, leadership, date of initiation, communication plan and process monitoring. The decisions made during the council meeting were communicated to all the unit staff. The council divided the responsibility for the information exchange and agreed to function as situational leaders to facilitate implementation. During this phase, the council met every other week to expedite the process; they utilised a flipchart display in the staff lounge to communicate about the progress of implementation and outcomes.

Some TeamSTEPPS Tools, for instance, Handoff, needed more preparation time to customise, and were alternated with those that did not require the same amount of preparation. Although the use of some Tools was situation-dependent, they were added to the implementation timeline to foster learning. Conflict resolution competencies, such as DESC (refer to table 1), were reviewed during Briefs and Debriefs to reinforce and explore if opportunities to utilise the competencies were availed. During this phase, the leadership made rounds on the unit and were available to support the new processes.

Simultaneously, the council addressed improvement opportunities on the unit, starting with things that they could directly impact, such as decreasing central-line infections, ventilator-

Table 1 TeamSTEPPS tools and strategies defined

TeamSTEPPS tools and strategies	Definitions
Brief	Planning; a 3–5 min session prior to start to discuss team formation, assign essential roles, establish expectations and climate, anticipate outcomes and likely contingencies
Huddle	Problem solving; ad hoc planning to re-establish situation awareness. Reinforcing plans already in place and assessing the need to adjust the plan
Debrief	Process improvement; informal information exchange session designed to improve team performance and effectiveness. An after-action review
STEP	A tool for monitoring situations in the delivery of healthcare. Status of the patient; team members; environment; progress towards goal
Cross-monitoring	An error-reduction strategy that involves: monitoring actions of other team members; providing a safety net within the team; ensuring mistakes or oversights are caught quickly and easily; watching each other's backs
Feedback	Information provided for the purpose of improving team performance. It should be timely, respectful, specific, directed towards improvement and considerate
Advocacy and assertion	Advocate for the patient; this is invoked when team members' viewpoints do not coincide with that of the decision maker. Assert a corrective action in a firm and respectful manner; make an opening, state the concern, offer a solution and obtain an agreement
Two-challenge rule	A constructive approach for managing and resolving informational conflict; we have different information. When an initial assertion is ignored; it is your responsibility to assertively voice your concern at least two times to assure it has been heard. The team member being addressed must acknowledge. If the outcome is still not acceptable take a stronger course of action and/or utilise a supervisor or chain of command. Empowers all team members to 'stop the line' if they sense or discover an essential safety breach
CUS	To be used <i>only</i> when appropriate; I am concerned; I am uncomfortable; this is a safety issue—stop
DESC script	A constructive approach for managing and resolving personal conflict, hostile and harassing behaviour. D, Describe the specific situation; E, Express your concerns about the action; S, Suggest other alternatives; C, Consequences should be stated
Collaboration	Achieves a mutually satisfying solution resulting in the best outcome, meeting goals without compromising relationships
SBAR	A framework for team members to effectively communicate information to one another. S—situation. What is going on with the patient? B—background. What is the clinical background or context? A—assessment. What do I think the problem is? R—recommendation. What would I recommend?
Call-out	Strategy used to communicate important or critical information
Check-back	Process of employing closed-loop communication to ensure that information conveyed by the sender is understood by the receiver as intended
Handoff	The transfer of information along with authority and responsibility during transitions in care across the continuum; to include an opportunity to ask questions, clarify and confirm

acquired pneumonia and improving throughput. It was validating to observe empowerment develop with the team's ability to rapidly brainstorm solutions. As the Pilot Unit was transitioning, word spread to other units which immediately adopted some of the ideas. While every unit had its unique set of challenges, subsequent transitions were easier, and we attribute this to favourable communication through the proverbial grapevine. TeamSTEPPS implementation for the entire organisation was completed in 15 months.

Phase 3—sustainment

Sustainment was planned from the preparation stage. The importance and relevance of TeamSTEPPS was communicated to everyone at the start of training by communicating its connection to the organisational vision and mission via the Collaborative Care Model. The message was that TeamSTEPPS was now the way we would conduct business.

Executive leadership at the pilot hospital played a crucial role in sustainment, choosing to continue as a team beyond implementation, and have evolved in their role and functions; the team continues to provide oversight and facilitate TeamSTEPPS, empowering and engaging staff through the council structure and contributing to sustainment of TeamSTEPPS. One year after implementation, all the pilot hospital units/departments were asked to disseminate their process changes and outcomes achieved through utilising TeamSTEPPS competencies at a site-wide poster session, which was open to the entire health system. The enthusiasm was contagious, and there was tremendous pride in displaying their achievements. This camaraderie and sharing enabled further team cohesion and learning. The tremendous

response convinced leadership to continue with these annual sessions. TeamSTEPPS competencies are reviewed annually and are part of the organisational orientation for new team members.

Spread: system-wide TeamSTEPPS implementation

The dramatic impact of TeamSTEPPS on the culture of the pilot hospital provided impetus to the health systems' executive leadership decision to implement TeamSTEPPS system-wide. A timeline for rapid, systematic and structured implementation was developed, (table 2).

Templates were developed for standardising implementation at the organisation and unit levels. Standardising the process enabled us to create a shared mental model about TeamSTEPPS rollout, and evaluate its progress. From 2009 to 2010, implementation was completed in 13 hospitals and two long-term care centres and outpatient areas. To date, 32 150 employees were trained. TeamSTEPPS is included in the annual mandatory training and orientation. Redosing is planned, and an online team site is available to share best practice. TeamSTEPPS tools and strategies serve as organisational process to support clinical process improvement.

EVALUATION AND RESULTS

Training was evaluated using Kirkpatrick's Model (21). 'Level I: Reaction' was assessed by participants' completion of course evaluation at the end of the training session; 92–96% rated the course as 'excellent', and 1–8% rated it as 'good'. 'Level II: Learning' was evaluated using TS Learning Benchmarks at the end of the training, verbally and as a group, enabling the instructors to give immediate feedback, lending further clarity.

Table 2 Key steps: implementation

Key steps in implementation of a patient safety solution	TeamSTEPPS offers
Identification of solution	<ul style="list-style-type: none"> ► Out-of-the box evidence-based solution ► Ready-to-use educational materials and curriculum <ul style="list-style-type: none"> – Modules in text and presentation format – A pocket guide for staff with basic concepts – Video scenarios to illustrate key concepts Workshop materials on change management, coaching and implementation ► Implementation templates ► Outcome measurement tools ► Minimal cost impact ► Simplicity, increasing its applicability
Training	<ul style="list-style-type: none"> Train-the-trainer program tailored to level of team involvement: ► 2.5-day Master Training for those who train ► 2-day Master Training for those who coach and lead ► 4–6 h fundamentals—direct care providers ► 1–2 h essentials—non-clinical support staff
Pilot implementation plan	<ul style="list-style-type: none"> Pilot site implementation affords some benefits, allowing for testing and design of: ► Training requirements and preferences ► Measures ► Roles and responsibilities ► Implementation plans, for instance, <ul style="list-style-type: none"> ► By service line, by department, by geography, etc. ► Sustainment and integration techniques ► Templates for spread
Implementation Plan	<ul style="list-style-type: none"> Implementation of TeamSTEPPS should be rapid, structured and systematic. Site preparation must include: ► Engaging leadership and identification of goals ► Site readiness assessment and Hospital Survey on Patient Safety Culture ► Determination of <ul style="list-style-type: none"> ► Sequence of training and implementation ► Training length depends on number of staff ► Infrastructure for implementation ► Communication plan ► Implementation begins when 60% of staff are trained <ul style="list-style-type: none"> ► Integrate teamwork competencies into daily practice ► Monitor processes and outcomes ► Time required depends on selected rollout sequence; a unit/department may require six months to embed TS tools in practice ► Sustain and Spread (see Integration into Organisation) ► Evaluation postimplementation (see Measurement)
Integration into organisation	<ul style="list-style-type: none"> Solutions may be embedded by weaving them into the fabric of daily practice and work. For instance: ► Included safety as a core value of the organisation <ul style="list-style-type: none"> ► Organisational care model is discussed at every training to underscore the link ► Presenting TS basic concepts during all on-boarding ► Included TS concepts in relevant policy and procedure ► In all departments, Brief, Debrief, Huddle and Handoff are core functional activities ► All Leadership participate in Master Training, serving as coaches and facilitators to ensure sustainment
Measurement	<ul style="list-style-type: none"> ► A pretraining assessment of organisational readiness ► A Teamwork Perception questionnaire ► A Teamwork Attitudes questionnaire ► Three AHRQ surveys on patient safety culture: <ul style="list-style-type: none"> ► Hospital survey on Patient Safety Culture ► Medical office survey on Patient Safety Culture ► Nursing home on Patient Safety Culture

AHRQ, Agency of Healthcare Research and Quality.

'Level III: Behavior' was assessed by appraising adoption of TeamSTEPPS competencies at the unit/department level using direct observation and anecdotes. Team competencies, such as Briefs, Debriefs, Huddles and Handoffs are embedded in daily routines at all our hospitals; others competencies are used in procedures, or as needed.

'Level IV: Results', the effects of team training was evaluated by assessing accomplishment of our goals of transformational change (building a culture of safety) and incremental change (continuous improvement) using Hospital Survey On Patient Safety Culture (HSOPSC) and targeted variables.

Transformational change

In the pilot hospital, the HSOPSC survey was conducted in 2007 (baseline), 2009 and 2010 (table 3). The 2009 results showed significant changes²² in the dimensions of Feedback and Communication, Overall Perception of Safety, and Staffing. Although the Dimension of Staffing showed the highest improvement, the actual number of staff had not been changed. This is a testament to teamwork effectiveness, although staffing had not increased, increased team collaboration contributed to the perception of staffing improvement. Most of the other dimensions either increased or remained unchanged. However,

Table 3 Pilot hospital results for 'Hospital Survey on Patient Safety Culture': difference in pre-TeamSTEPPS versus post-TeamSTEPPS implementation

Dimensions	Improvement from 2007 to 2009 (%)*	Improvement from 2009 to 2010 (%)	Improvement from 2007 to 2010 (%)
Communication/openness	+1	+6.7	+7.7
Feedback and communication about error	+4	+5.3	+9.3
Frequency of events reported	-1	+3.6	+2.6
Hospital handoffs and transitions	0	+11.30	+11.3
Hospital management support for patient safety	+3	+8	+11
Non-punitive response to error	+3	+12.9	+15.9
Organisational learning—continuous improvement	-2	+13.7†	+11.7†
Overall perceptions of safety	+6	+5.8	+11.8
Staffing	+8	+7.8	+15.8
Supervisor/Manager expectations and actions promoting patient safety	0	+10.9†	+10.9†
Teamwork across hospital units	+3	+11.1	+14.1
Teamwork within units	-2	+13.9†	+11.9†

*2007—Pre-TeamSTEPPS.

†Area of strength.

in 2010, all dimensions show significant improvement with three dimensions, (Organisational Learning, Supervisor/Manager Expectations, and Teamwork within Units), becoming organisational strengths (>75%).

The system-wide results show the same trend seen in the results of the pilot hospital pre-TeamSTEPPS and post-TeamSTEPPS validating Kotter's observation,²³ 'real transformation takes time'. Comparison of system-wide results of HSOPSC from 2009 (prior to TeamSTEPPS implementation) to 2011, showed significant improvement in the dimensions of 'Feedback and Communication about Error' 'Frequency of Events Reported', 'Hospital Handoff and Transitions', 'Staffing' and 'Teamwork across the Units'. Considered as an area of strength with scores >75% were 'Organisational Learning' and 'Teamwork within Units'.

Incremental change

Incremental changes were assessed by comparing preintervention and postintervention measures of variables depicting the change. Examples include reduction of nosocomial infections, falls, improvement in process measures and decrease in adverse outcomes, birth trauma and return to the operating room in perinatal services.²⁴

We believe that TeamSTEPPS served to optimise other initiatives and impacted the organisations' deep commitment to quality; NSLJHS was honoured as the recipient of the National Quality Forum 2010 National Quality Healthcare Award.

To date, 300 Collaborative Care Councils are established across the 14 hospitals, ambulatory care and emergency medical services of the health system. The councils keep the teams engaged, and the team engagement improves our care delivery.

DISCUSSION

Based on our findings in the areas of transformational and incremental changes, team training works. This finding is consistent with previous reports of team training impact, including improving team effectiveness and team training outcomes,^{7 25} and patient and organisational outcomes.²⁶ The meta-analysis conducted by Salas *et al* supports team training as an appropriate intervention for influencing team processes and performance.²⁷ Our findings are similar to recent reports of the impact of team training using TeamSTEPPS/modified

TeamSTEPPS.^{10 28 29} However, methodological constraints still prevent us from directly correlating team training to clinical outcomes.³⁰

LIMITATIONS

The scope of our implementation and train-the-trainer model required a large number of trainers. Although the curriculum is standardised, we could not monitor every training session for delivery of content or unique attributes of the trainers that could positively or negatively impact the training.

Although our TeamSTEPPS implementation was planned and organised to be rapid, we could not control the onslaught of ongoing changes or other initiatives impacting patient safety. This adds to the difficulty in attributing TS as directly impacting several outcomes. In addition, logistical constraints of implementation made it difficult to assign control units which could have strengthened our preintervention and postintervention comparisons.

LESSONS LEARNED

The implementation of TeamSTEPPS for team training and engagement has taught us many valuable lessons, (table 4).

Accountability

It is essential to establish a partnership between the team facilitating TeamSTEPPS implementation and the organisation. The

Table 4 Lessons learned table

Lesson learned	Key points
Accountability	Partnership, ownership, specify roles and responsibilities
Leadership	Engage executive leadership to drive and monitor change
Training	Multiskilled, interdisciplinary trainers
Dosing	Refresh regularly and as needed
Implementation	Rapid, structured and systematic rollout
Physician participation	Engage in planning, training and implementation
Integration	Embed in processes, policy, on-boarding and education

We found these factors critical to the successful implementation of this program.

organisation should select a responsible point person with clear delineation of roles and responsibility. We have subsequently used two point persons at the organisational level; one focusing on implementation of TeamSTEPPS and the other facilitating the Collaborative Care Councils.

Leadership

The role of the Executive Leadership Team is crucial in the implementation and sustainment of TeamSTEPPS. The executive team at the pilot hospital has evolved to create processes to facilitate the Collaborative Care Councils and TeamSTEPPS; they established processes to drive and monitor the changes, align activities with the mission and vision of the organisation, as well as check-back loops to exchange information. We consider this as best practice for ongoing engagement of the leadership and frontline for sustaining TeamSTEPPS and Collaborative Care Councils.

All the hospital leadership must attend Master Training sessions to enable informed decisions and participation. It is very important that they understand the TeamSTEPPS strategies in order to be a champion, role model and coach for the rest of the hospital. Additionally, leadership rounding focused on TeamSTEPPS heightens accountability and ownership.

Leadership support and involvement at all levels of the institution is critical for success. It is essential for the nurse manager and physician leader of patient care units to be champions and role models for the success of TeamSTEPPS. We also noted the importance of engaging informal leaders who often emerged through development of the council structure.

Training

Trainers should be selected carefully with consideration for their teaching and group management skills; along with the TeamSTEPPS content, trainers have to be adept at facilitating honest interactions, maintaining focus and leading the group. We have often paired trainers with content and educational process expertise to get the desired skill sets.

The plan for training should be based on the sequence of TeamSTEPPS implementation in the organisation with minimal time lag between training and implementation. Departments, disciplines and services that interact daily should be cohorted for training. This allows for the seamless integration of the TeamSTEPPS strategies in daily practice.

Team training

An interdisciplinary approach to training is essential to the acceptance and commitment of the staff. This means having an interdisciplinary team of trainers as well as attendees. Interdisciplinary attendance, including physicians, at training classes provides varied perspectives to the learning and discussion, and demonstrates organisational commitment to participants in a tangible manner. Without fail, in the few classes held that did not have interdisciplinary attendance, this was mentioned and perceived as a negative by staff.

Teams attending training together have the opportunity to engage in team building and start the TS implementation dialogue in an empowering environment.

Dosing

It is important to note that refresher training (dosing) will have to be done at intervals to maintain knowledge and practice of strategies. A study done at the health system showed a significant decrease in retention of knowledge and attitudes between three months and six months post-TeamSTEPPS training validating the need for redosing.

Implementation

The process of implementation should be standardised for all units. It must be rapid, systematic and structured. Integration of strategies should begin when 60% of the unit or department staff has completed training.

Physician participation

One of the critical factors for a successful implementation is physician involvement. Physicians need to be part of the entire process—planning, training and rollout. If the physicians do not believe that teamwork is essential for reducing errors and improving patient outcomes, it will be extremely difficult to implement team training. Physicians must be engaged as champions who believe in the importance and value of the training.³¹ Our experience demonstrated that physicians responded best to training conducted by other physicians. It is important that physicians are seen as leaders in TeamSTEPPS training and rollout.

Integration

It is important for TeamSTEPPS not to be seen as just another initiative that will be gone in a year or two. This can be

Table 5 Summary: implementation challenges and strategies for success

Challenges	Strategies for success
Mandating attendance elicits negative attitudes in attendees	Offer classes as often as necessary, round the clock, evenings and weekends, off-site and on-site
Private physician engagement is challenging	Classes can be segmented and delivered over time at forums where these physicians may participate, such as Grand Rounds. Trainers also went to physician offices and delivered classes and materials, although this is not ideal in smaller practices, as it negates the interdisciplinary aspect
Trainer skillset is very important	Trainers must be accustomed to dealing with a variety of attitudes and behaviours without internalising; managers make excellent trainers. Our trainers have dealt with scepticism, scorn and hostility directed at themselves, heated discussion between participants and a variety of other passive-aggressive behaviours from their colleagues
Leadership engagement	In a multientity organisation, engage senior leadership first. Then engage site leadership according to implementation plan and senior leadership can assist if needed. Leadership participation in training and implementation is perceived very positively by staff. Leadership engagement in sustainment activities is also essential
Interdisciplinary classes are preferable	Staff practices in an interdisciplinary environment; so should they train. It is best to engage all the roles participating in a departments' work together in training. For instance, on a general surgical unit, the daily team might include surgeons, surgical residents or fellows, physician assistants, nurse practitioners, nurses, pharmacists, nursing assistants, ward clerks, environmental/housekeeping staff, respiratory therapists, physical therapists, clergy, volunteers, etc. As much as possible, these roles should train together

accomplished by embedding TeamSTEPPS strategies into all the organisation's processes; quality orientation of new staff, annual competencies, human resources and policies. Standardisation of the Collaborative Care Council agenda throughout our organisation and development of hospital-wide Central Councils created a forum for sharing best practices, accountability, sustainment and oversight for continued integration of TeamSTEPPS into practice.

In conclusion, cultural transformation is a complex process with multiple factors (table 5) influencing its success. Therefore, it is essential to adopt solutions, such as TeamSTEPPS, that are applicable to all the members of the organisation. Adopting solutions that can be easily integrated into clinical routines or workflow increases compliance and engages front-line staff ensuring sustainability. Integrating TeamSTEPPS with our Collaborative Care Councils provides the infrastructure and processes to enhance team performance with effective mechanisms for communication, problem solving and engagement of large, interdisciplinary teams impacting patient safety. The Collaborative Care Model and TeamSTEPPS are now our way of life.

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Contributors Both authors meet conditions 1, 2 and 3 according to ICMJE guidelines. Please see below for specific contributions. LT: coordinated the design of organisational model (Collaborative Care Model); designed TeamSTEPPS implementation for pilot hospital and system-wide; facilitated baseline and ongoing AHRQ Patient Safety Survey and acquisition of data, analysis interpretation; drafted and revised manuscript, final approver for publication; approved the final version to be published. CG: facilitated implementation of Collaborative Care Councils (infrastructure to support the organisational model system-wide); facilitated implementation of TeamSTEPPS system-wide, including facilitating incremental changes using TS; drafted and revised manuscript, approved version to be published; approved the final version to be published.

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Effect of obstetric team training on team performance and medical technical skills: a randomised controlled trial

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Objective To determine whether obstetric team training in a medical simulation centre improves the team performance and utilisation of appropriate medical technical skills of healthcare professionals.

Design Cluster randomised controlled trial.

Setting The Netherlands.

Sample The obstetric departments of 24 Dutch hospitals.

Methods The obstetric departments were randomly assigned to a 1-day session of multiprofessional team training in a medical simulation centre or to no such training. Team training was given with high-fidelity mannequins by an obstetrician and a communication expert. More than 6 months following training, two unannounced simulated scenarios were carried out in the delivery rooms of all 24 obstetric departments. The scenarios, comprising a case of shoulder dystocia and a case of amniotic fluid embolism, were videotaped. The team performance and utilisation of appropriate medical skills were evaluated by two independent experts.

Main outcome measures Team performance evaluated with the validated Clinical Teamwork Scale (CTS) and the employment of

two specific obstetric procedures for the two clinical scenarios in the simulation (delivery of the baby with shoulder dystocia in the maternal all-fours position and conducting a perimortem caesarean section within 5 minutes for the scenario of amniotic fluid embolism).

Results Seventy-four obstetric teams from 12 hospitals in the intervention group underwent teamwork training between November 2009 and July 2010. The teamwork performance in the training group was significantly better in comparison to the nontraining group (median CTS score: 7.5 versus 6.0, respectively; $P = 0.014$). The use of the predefined obstetric procedures for the two clinical scenarios was also significantly more frequent in the training group compared with the nontraining group (83 versus 46%, respectively; $P = 0.009$).

Conclusions Team performance and medical technical skills may be significantly improved after multiprofessional obstetric team training in a medical simulation centre.

Keywords Education, multiprofessional, obstetric emergency situations, simulation, team training, training.

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Introduction

In the UK, the Confidential Enquiry into Maternal and Child Health (CEMACH) identified substandard care in a large proportion of preventable maternal and perinatal deaths, ranging from 45 to 73%.^{1–3} The reports of both CEMACH

and the Institute of Medicine (USA) have advocated the introduction of interdisciplinary team training.^{2,4} The underlying message from these two reports is that communication and coordination of the care team need to be improved.

Local training programmes on an individual basis already occur frequently. However, if the care team, not

the individual, is responsible for most clinical errors, then team training might be more effective than training at an individual level. Such multiprofessional team training can easily be applied to obstetric emergency situations, because different healthcare professionals and disciplines work together in the labour ward. Grogan et al.⁵ already demonstrated that team training in crew resource management leads to a positive attitude of trainees towards dealing with fatigue, teambuilding, communication, recognising dangerous situations and decision making.

To evaluate these medical team training courses, Kirkpatrick's theoretical model for the evaluation of training can be applied (Figure 1).⁶ It consists of four levels of training achievement with the bottom two levels referring to the reaction (satisfaction after training) and the improvement in knowledge of the trainee. Level three measures the implementation of learned skills and behaviour into clinical practice. The highest level relates to the effect of training on measurable clinical outcome(s).

Few articles evaluating the effect of teamwork training with simulation models have been published, and even fewer have examined objective measurements of improvement in the management of acute obstetric emergencies.⁷ There is only one retrospective study at the fourth level of Kirkpatrick, describing a significant effect of team training on perinatal outcome, using Apgar scores.⁸ At the third level of Kirkpatrick, Crofts et al.⁹ identified a significant effect of training individuals on clinical skills during an *in situ* simulation on shoulder dystocia. However, there are no randomised controlled trials evaluating the effectiveness of team training in obstetric emergencies with simulation methods at the third or fourth level of Kirkpatrick's model.

As a consequence of the paucity of evidence, we performed a multicentre randomised controlled trial to investigate the effectiveness of team training in a medical simulation centre.¹⁰ The primary outcomes for this randomised controlled trial are based on maternal and perinatal outcomes, i.e. the fourth level of Kirkpatrick's model. For this report we evaluated the clinical behaviour of the medical team more than 6 months after team-based training,

i.e. level three of Kirkpatrick's model. We investigated the hypotheses that obstetric team training in a medical simulation centre will improve the team clinical performance and increase the employment of essential clinical skills assessed using an unannounced clinical simulation.

Methods

The current study is part of a multicentre cluster design randomised controlled trial to assess the effectiveness of team training in a medical simulation centre.¹⁰ Eligible units were hospital-based obstetric departments in all teaching and nonteaching hospitals in the Netherlands with at least 1000 deliveries per annum. Teaching hospitals provide training for residents in obstetrics and gynaecology, whereas nonteaching hospitals do not provide such training. Obstetric units with an existing local multidisciplinary team training course could not participate. To prevent data contamination, the included units were not allowed to do any medical team training until the study period was ended. In addition, the results of the present study will not be published before the follow-up of the initial randomised controlled trial is completed. As this was a cluster randomised clinical trial allocating interventions at a group level, the institutional review board of the Máxima Medical Centre judged that consent from participating patients was not needed. The primary outcome of this randomised controlled trial was the number of obstetric complications during the first year after team training. In the current study we only report on team performance and medical technical skills more than 6 months after the training intervention.

The units were randomly allocated to the intervention and control groups using a computer-generated list that was stratified for teaching and nonteaching hospitals. Obstetric units allocated to the intervention group received a 1-day team training course in a medical simulation centre in Eindhoven. Eighty percent of the training time is given to crew resource management and 20% to medical technical skills. Each obstetric unit consisted of a number of multiple multiprofessional teams consisting of a gynaecologist, a midwife, a resident and two or three nurses. Each team was formed around a single gynaecologist. In total 74 teams, corresponding to the number of employed gynaecologists in the 12 units allocated to the intervention group, were included for training. Team training was delivered using high-fidelity mannequins by a gynaecologist and a communication expert. All the training instructors underwent an instructor training course for running simulation-based trainings, with emphasis on crew resource management. The birthing simulator Noelle™ (Gaumard, Miami, FL, USA) or the Emergency Care Simulator ECS™ (METI, Sarasota, FL, USA) were used in six obstetric emergency scenarios: fetal distress including cardiotocographic

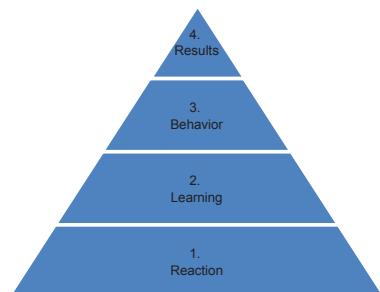


Figure 1. Kirkpatrick's model for the evaluation of training.

analysis, shoulder dystocia, postpartum haemorrhage, umbilical cord prolapse, eclampsia and resuscitation of a pregnant woman. These scenarios were based on national and international guidelines from The Dutch Society of Obstetrics and Gynaecology, Royal College of Obstetricians and Gynaecologists and (Managing Obstetric Emergencies & Trauma [MOET]) in the UK.¹¹ Every scenario started with a briefing by an introductory video for approximately 5 minutes, where the clinical situation is performed by actors on a wide screen. After this introduction the team moved to the simulation delivery room where they were required to manage the simulated patient. All the scenarios, lasting approximately 15 minutes, were videotaped. After finishing each scenario, the team returned to the briefing room for a 30-minute debriefing session. Feedback on teamwork and the application of medical technical skills was provided by reviewing the relevant video recordings. Feedback on teamwork concentrated on components of crew resource management, i.e. communication, leadership, decision making and situational awareness. All individual teams from each hospital were trained within a time period of 4 weeks.

More than 6 months after completing these training courses, an unannounced *in situ* clinical simulation with two scenarios, shoulder dystocia and amniotic fluid embolism, was conducted at all obstetric units (in both the intervention and control group) recruited into the study. At the time of their training the participants were aware that an unannounced *in situ* simulation would take place more than 6 months later. Only a single person at each of the obstetric units was contacted in advance to organise the use of one of the delivery rooms in the unit for the purpose of the clinical simulation. All the on-duty individuals who were allocated to staff the delivery room participated in the simulation. For both scenarios a standardised script was used. The scenario started with an actress conducting a delivery. Because of difficulties related to the delivery, the (simulated) case was handed over to a clinical midwife or resident obstetrician. The intention was that participants were unaware of the simulated setting until they entered the delivery room. In the first scenario on shoulder dystocia, a hybrid high-fidelity simulation with the PROMPT™ birthing simulator (Limbs & Things, Bristol, UK) was used. The simulation continued until the baby was delivered in the all-fours position. If the all-fours manoeuvre was not applied, the baby was delivered anyway. Between the first and second scenario the participants left the delivery room, without knowing whether the *in situ* simulation was still ongoing. The next scenario on amniotic fluid embolism required the resuscitation of the pregnant woman. For this scenario we used a mannequin called Resusci Anne™ (Laerdal, Stavanger, Norway), which was modified into a pregnant woman. The

simulation was terminated after delivery of the baby by a perimortem caesarean section or when the medical team failed to make any progress in the management of the scenario. If help was requested, one of the investigators could attend, but would not perform any clinical tasks unless requested to do so. The participants were encouraged to ask for help from colleagues as well. Both scenarios lasted a maximum of 10 minutes and were videotaped. To prevent any learning effect of the *in situ* simulation in the control group, no feedback on teamwork and medical skills was provided to participants in both groups after the simulation.

The Clinical Teamwork Scale (CTS) was used for assessment of team performance in a simulated obstetric emergency context.¹² At the time of designing this study, it was the only validated rating scale designed specially for obstetric team performance. The CTS has been reported to have substantial agreement (Kappa 0.78) and score concordance (Kendall coefficient 0.95) between raters, and a high inter-rater reliability (interclass correlation coefficient 0.98). It has been developed based on the important topics in crew resource management. The CTS consists of 15 items in five different teamwork domains: communication, decision making, role responsibility, situational awareness/resource management and patient-friendliness. For all 15 items, a rating scale ranging from 0 to 10 was adopted except for the ninth item. The ninth item is about the presence of target fixation (yes or no). Target fixation exists when team members exhibit tunnel vision that prevents progress from being made in the management of the scenario.¹²

We also investigated whether medical team training can lead to the acquisition of medical technical skills. To assess this, we ascertained whether a prespecified, recommended but unfamiliar obstetric procedure was employed in each of these obstetric emergencies. For the scenario on shoulder dystocia, we have chosen the manoeuvre in which the baby was delivered in an all-fours maternal limbs position (all-fours manoeuvre). Although this manoeuvre is recommended as a useful manoeuvre in several national guidelines on shoulder dystocia (e.g. Dutch Society of Obstetrics and Gynaecology, Royal College of Obstetricians and Gynaecologists) and international courses (MOET; Managing Obstetric Emergencies & Trauma) many obstetric teams are not familiar with it.^{11,13–15} In the second scenario a perimortem caesarean section had to be carried out within 5 minutes. Many obstetric teams have little experience with this procedure, because of the low incidence of resuscitations of pregnant women.

The ascertainment of whether both outcome measures were present in the scenarios was conducted by an expert panel of two trained assessors. They were not involved in the training nor in performing the *in situ* simulations. Both

were obstetricians who were familiar with the principles of crew resource management and the use of CTS. Although the study participants were aware of the arm of the study to which they were allocated, the individuals in the expert panel were kept blinded to the study allocation.

The calculation on the power of the study was based on the primary outcome measures of this study, i.e. perinatal and maternal outcomes throughout the first year after intervention, and not on the secondary outcomes for the purpose of this report. The perinatal and maternal complications are defined as the number of neonates with perinatal asphyxia (5-minute Apgar score < 7 or arterial umbilical pH < 7.05), hypoxic ischaemic encephalopathy, number of neonates with damage caused by shoulder dystocia (e.g. lesion of brachial nerve plexus, clavicle fracture), number of women with eclampsia, number of women with severe postpartum haemorrhage (more than four blood transfusions of packed cells, embolisation, hysterectomy).¹⁰ We expected the incidence of adverse perinatal and maternal outcomes in the control group to be 15%. Based on this assumption, we calculated that a sample size of 24 hospitals with at least 200 deliveries per year was needed to give a power of 80% to detect a reduction in adverse perinatal and maternal outcomes from 15 to 5% (using a two-sided type 1 error of 5%) in the intervention group.

Data management and analysis were performed using SPSS (Statistics 18.0; SPSS Inc., Chicago, IL, USA). The CTS scores were described using the median (range). To compare the differences in team performance between the intervention and control groups, the total median and median scores of each of the items of the CTS were calculated and compared using the Mann–Whitney *U* test. The frequency of application of the relevant obstetric procedures in the two scenarios was compared by using a chi-square test. When indicated, a Fisher's exact test was used instead of a chi-square test. *P*-values ≤ 0.05 were considered to indicate statistical significance.

Results

The obstetric departments in 36 hospitals were invited to participate in this multicentre cluster randomised controlled trial. Four hospitals declined participation and eight hospitals did not meet the inclusion criteria for this study. An overview of enrolment of the various obstetric departments is presented in the CONSORT flowchart (Figure 2). Eventually, 24 obstetric departments were included and randomly assigned to either team training in a medical simulation centre (*n* = 12) or to a control group (*n* = 12). In the training group, a total of 74 clinical teams were identified for training. The training and nontraining groups were comparable in relation to the number of teaching

hospitals in each group, the total and mean number of deliveries per year and the staffing level (Table 1). All obstetric departments that were randomly assigned to the intervention group received the team training course. There were no hospitals lost to follow up in either the training or nontraining group.

The 24 hospitals were recruited into the study from January to November 2009. Participating clinical teams in the intervention group visited the simulation centre for training from November 2009 until July 2010. *In situ* simulations were performed 6–10 months after the study randomisation, with a mean interval of 8.27 months (8.43 ± 1.62 months for the intervention group and 8.12 ± 1.36 months for the control group; *P* = 0.6).

In each obstetric unit, in both the intervention group and the control group, the multiprofessional on-call team was targeted on the day the *in situ* clinical simulation was conducted. Each team participated in both the clinical scenarios. Consequently, the *in situ* simulations yielded a total of 48 video recordings for the assessment of team performance and medical technical skills.

Team training was associated with a higher overall median CTS score. The total median score of all items was significantly higher in the training group (median 7.5, range 2.0–8.5) than in the nontraining group (median 6.0, range 2.0–8.0; *P* = 0.01) (Table 2). Comparison of the median scores on the five separate teamwork domains of the CTS showed a statistically significant difference in communication (*P* = 0.008) and decision making (*P* = 0.01) between the training and nontraining groups (Table 2). The differences between the remaining three domains of the CTS were not statistically significant.

For the analysis of the quality of medical technical skills employed in the two clinical scenarios, only 45 of the 48 video recordings could be used because there was a technical problem within the simulated scenario in three cases. All these technical problems were encountered in the first scenario on shoulder dystocia with the PROMPT™ birthing simulation. Eventually, 23 video recordings from the 12 training units and 22 from the 12 nontraining units were available for analysis.

The required obstetric procedures (delivery of the baby in the all-fours maternal position for the scenario on fetal shoulder dystocia and the performance of a perimortem caesarean section within 5 minutes in the amniotic fluid embolism scenario) were performed in 19 of the 23 *in situ* simulations recordings (83%) in the trained units compared with 10 of the 22 recordings (46%) in the untrained units (*P* = 0.009). Nine trained teams used the all-fours manoeuvre compared with four nontrained teams (*P* = 0.08). Ten trained teams performed a perimortem caesarean section in comparison with six nontrained teams (*P* = 0.193).

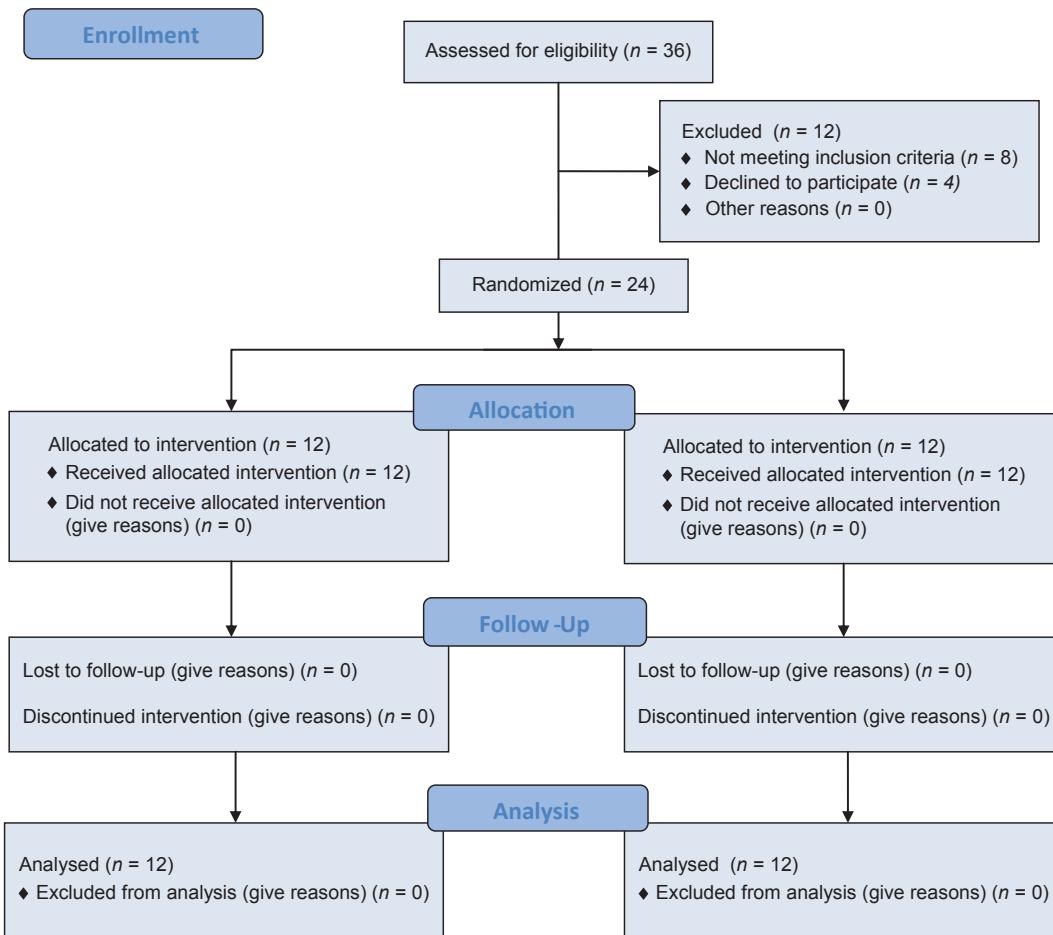


Figure 2. The enrolment of Dutch obstetric departments presented in the CONSORT flowchart.

Table 1. Baseline characteristics of training and nontraining groups

Training group (hospitals; n = 12)	Nontraining group (hospitals; n = 12)
Teaching hospitals (n)	5
Total deliveries per year (n)	14 726
Mean deliveries per hospital	1230
Gynaecologists (n)	74
Midwives (n)	79
Residents (n)	36
Nurses (n)	282

Discussion

In this multicentre randomised clinical trial we found a significant improvement in team performance and a significant increase in the use of new medical technical skills 8 months after obstetric, multiprofessional team training in

a medical simulation centre. The training courses focused on both crew resource management (for 80%) and medical technical skills (for 20%).

Three previously reported studies have shown no benefit from isolated teamwork theory training on team performance.^{16–18} Nevertheless, the Institute of Medicine suggested that the training of medical teams might be an important contributing factor in the improvement of health care.⁴ Besides, in two of three studies only obstetricians and midwives were involved and it is also unclear whether the improvement of the teamwork was only applicable to specifically constructed teams or whether this effect would still be present when the composition of such teams was more random.^{17,18} For these reasons, we have deliberately designed our study using teamwork training, based on crew resource management, in combination with training of medical skills.

The training group had a significantly higher median and overall score on the CTS. However, it is clear that in particular ‘communication’ and ‘decision making’ are significantly better in the training group. This remarkable

Table 2. Comparison of team performance between training and nontraining groups, assessed by the CTS

	Training group Median (min–max)	Nontraining group Median (min–max)	P-value
Total median score on the CTS	7.5 (2.0–8.5)	6.0 (2.0–8.0)	0.014
Per item			
1. Overall score	7.0 (2.0–8.0)	6.0 (1.0–8.0)	0.022
2. Overall communication	7.0 (3.0–8.0)	4.5 (2.0–8.0)	0.008
3. SBAR	7.0 (0.0–8.0)	4.0 (1.0–8.0)	0.007
4. Transparent thinking	7.0 (2.0–8.0)	5.0 (2.0–8.0)	0.015
5. Directed communication	7.0 (4.0–8.0)	5.0 (1.0–8.0)	0.002
6. Closed loop	7.0 (3.0–8.0)	4.5 (0.0–8.0)	0.002
7. Overall situational awareness	7.5 (2.0–9.0)	7.0 (1.0–8.0)	0.078
8. Resource allocation	7.5 (1.0–9.0)	6.5 (2.0–8.0)	0.220
9. Target fixation (See Table 3)		(See Table 3)	0.666
10. Overall decision making	8.0 (2.0–9.0)	7.0 (2.0–8.0)	0.012
11. Prioritise	7.5 (2.0–9.0)	7.0 (1.0–8.0)	0.025
12. Overall role responsibility	8.0 (1.0–9.0)	7.0 (3.0–8.0)	0.118
13. Role clarity	8.0 (0.0–9.0)	7.0 (3.0–8.0)	0.082
14. Perform as a leader/helper	8.0 (1.0–9.0)	7.0 (3.0–8.0)	0.170
15. Patient friendly	7.0 (2.0–8.0)	7.0 (3.0–8.0)	0.448

SBAR, situation, background, assessment, recommendation.

Table 3. Comparison of the presence of target fixation (item 9 of the CTS) between training and nontraining groups

Item 9	Training group (n)	Nontraining group (n)	Total
No target fixation	22	20	42
Target fixation	2	4	6
Total	24	24	48

improvement could be explained by the well-defined nature of the sub-items concerning communication. These sub-items, i.e. SBAR (situation, background, assessment, recommendation), closed loop and directed communication, are well described and easy to understand. Therefore these items might be more easily implemented. In contrast, role responsibility and situational awareness are more dependent on the already existing behaviour of the care team. Changing this behaviour will comprise more than teaching

new communication tools in a 1-day course and will remain a challenge.

The effect of team training on team performance and the appropriate employment of medical technical skills reported in this study is applicable to level three of Kirkpatrick's model on the evaluation of training, i.e. the implementation of behaviour and skills in practice. Previous research conducted at a single centre has also reported a similar improvement in such skills.^{9,16} However, this earlier research included obstetricians and midwives, but allocated them to different roles from their own normal professional responsibilities. Furthermore, the trainees in one of these studies were tested only 3 weeks following training, which may result in the assessment of a temporary learning effect rather than a permanent change in clinical behaviour.⁹

It could be argued that the relatively small number of clinical teams tested during the *in situ* simulation is a limitation of our study. The composition of these teams (which is dependent on the on-call rota) could also have been different from those that underwent the team training. However, we assumed that simultaneous training of different healthcare professionals would lead to a change in work ethics, which is not dependent on the composition of a specific team. Our aim was to perform an unannounced clinical assessment, which would represent the real-life team performance and skills of the medical on-call team. Despite this potential limitation, we still demonstrated a significant improvement in the performance and skills of the trained units compared with the untrained units. We believe that the assessment of the on-call team is a perfect representation of the real-life effect of the training on the multiprofessional staff and therefore should not be interpreted as a limitation.

Another limitation of our study might be the employment of the methods of evaluation of the acquisition of medical technical skills. Because of the paucity of validated rating scales to assess medical team skills available for obstetric emergencies, we decided to use the presence of predefined obstetric procedures in the emergency situations. It indicates the ability to learn recommended but unfamiliar medical procedures by team training. However, the development of a validated rating tool for the assessment of medical technical skills is a subject for future research.

Team training has been implemented in a wide spectrum of disciplines in medicine. Disciplines like anaesthesia, surgery, obstetrics and paediatrics are frequently involved in simulation-based (team) training research. Nevertheless, there was still a paucity of good-quality evidence for the effect of team training on Kirkpatrick's level three and level four outcomes.¹⁹ Our study adds further evidence for level three outcomes of Kirkpatrick's model. We expect that the results of our study could easily be applied to different

disciplines. Further research should focus on the evaluation of the effect of training on measurable clinical outcomes.

Disclosure of interests

All authors declare that they have no financial, personal, political, intellectual or religious competing interests.

Contribution to authorship

SGO, BWM and SH were involved in conception and design of the study. AF and JV performed the *in situ* simulations. AERM and LDW-Z performed the assessment of the video recordings. AF and SH performed the statistical analyses. AF, SGO and BWM drafted the manuscript. JV, AERM, LDW-Z and SH reviewed the manuscript.

Details of ethics approval

As this was a cluster randomised clinical trial allocating interventions at group level and not at patient level, the institutional review board of the Máxima Medical Centre judged that consent on the level of the patient was not needed. We confirm that the institutional review board decided that an ethical approval was not needed for this trial design in the Netherlands.

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