


# A lifeline: enhancing neonatal central venous catheter safety

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## SUMMARY

Implementation of a traffic light system for reviewing central lines in a UK based tertiary neonatal unit.

## THE PROBLEM

The use of central venous catheters (CVCs) is paramount for delivering neonatal intensive care as they enable the delivery of intravenous fluids, parenteral nutrition (PN) and medications. Malpositioned umbilical venous catheters and percutaneously inserted central catheters (PICCs) can cause serious harm to our vulnerable infants. Such complications include hepatic injury, cardiac arrhythmias and cardiac tamponade.<sup>1</sup>

The British Association of Perinatal Medicine (BAPM), with the support of the Patient Safety Domain of NHS England, developed widely accepted national standards to reduce the incidence of complications associated with neonatal CVCs.<sup>1</sup>

This quality improvement project was initiated after two episodes of cardiac tamponade occurred in infants in a tertiary neonatal unit. The investigation highlighted that they were caused by malpositioned CVCs. Given the serious safety implications, change was required.

## AIMS

1. To ensure CVC insertion for neonates is performed as per national guidance, securing of the device is optimal and assessment of the line tip is consistent and clearly documented on the unit's proformas and everyday ward round entries.
2. To decrease the percentage of incorrectly positioned catheters to below our median baseline within 6 months from the start of the project.
3. To ensure the changes implemented are sustained.

## MAKING A CASE FOR CHANGE

Following the investigation into two serious events, the findings were

disseminated locally, and this raised awareness regarding the need for change. A collaborative 'Central Line Quality Improvement Group' was established to improve practice, consisting of doctors from all levels of training, advanced neonatal nurse practitioners (ANNPs) and the supervising consultant. Stakeholders including radiologists and radiographers were involved in the design of the proposed interventions. A retrospective case analysis highlighted that 43 out of 156 (27.5%) CVCs were malpositioned between July and November 2021. The Model for Improvement was used to guide our work.<sup>2</sup>

## IMPROVEMENTS

To understand barriers to the safe insertion and monitoring of neonatal venous catheters, several factors were mapped using a fishbone diagram (figure 1). Insight was gained from senior members of the team, including nursing staff and ANNPs.

To obtain the baseline data, CVCs inserted from 1 July 2021 until 31 November 2021 were identified using the national neonatal recording system, Badgernet. 'Central line data' for 104 babies (156 lines) of all gestations and weights were extracted. 29 babies were excluded due to having catheters inserted either in another regional neonatal unit or in theatre by interventional radiologists.

For each line, the position on the X-ray was assessed against a traffic light system, which was created by the QI team (see figure 2).

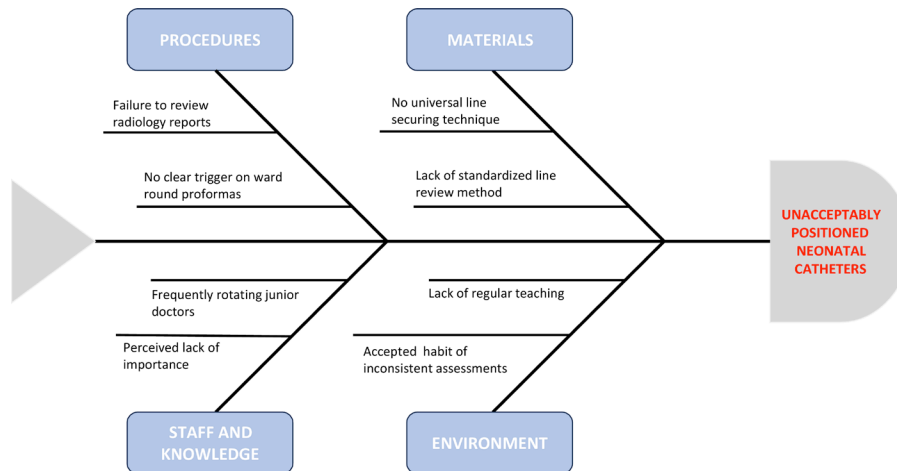
Each of the interventions was tested using plan-do-study-act (PDSA),<sup>2 3</sup> with some involving more than one test cycle (see table 1). Data was collected following each intervention and percentages were calculated. All data were collected by the project lead to ensure consistency.

The above interventions have continued to be supported through frequent



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**Figure 1** Fishbone diagram mapping existing barriers to safe insertion and monitoring of neonatal venous catheters (Leeds Teaching Hospitals NHS Trust).

education sessions and e-mail distribution of key learning points. This is only sustainable while actions are owned by permanent staff members.

**Outcomes**

A total of 333 catheters were reviewed over a 10-month period. The median baseline on the run chart (figure 3) for malpositioned lines was two. Results from PDSA cycle 2 onwards were consistently below the median, indicating a statistically significant improvement. Since the implementation of PDSA cycle 2, the number of malpositioned lines has consistently remained below the baseline (a run of 18 points). A run of 7 or more data points indicates a significant change ( $p \leq 0.001$ ) and a sustained improvement.

**LEARNING AND NEXT STEPS**

This QI project highlights that by implementing small and practical changes to everyday clinical care, patient

safety can be optimised. This project reduced the number of unacceptably positioned catheters from 27.5% to 6.8%.

One concern was that no reason(s) were identified for the sharp and sustained increase in the number of ‘red lines’ in October to November 2021. Awareness of the two catastrophic events was associated with a decrease in malpositioned catheters. This initial decrease is most likely a result of heightened anxiety and hypervigilance post-events. However, it was not until the first intervention was tested that the frequency of malpositioned catheters reduced below the median baseline. The run chart shows that this reduction was then maintained over a period of 19 weeks (1 on the median). Furthermore, after PDSA 4, we observed zero malpositioned lines for two consecutive weeks for the first time in the 10 months of monitoring.

**Figure 2** Traffic light guide to neonatal central venous catheter position, PICC line dressing guide and ‘Am I X-Ray Ready’ poster. PICC, percutaneously inserted central catheters.

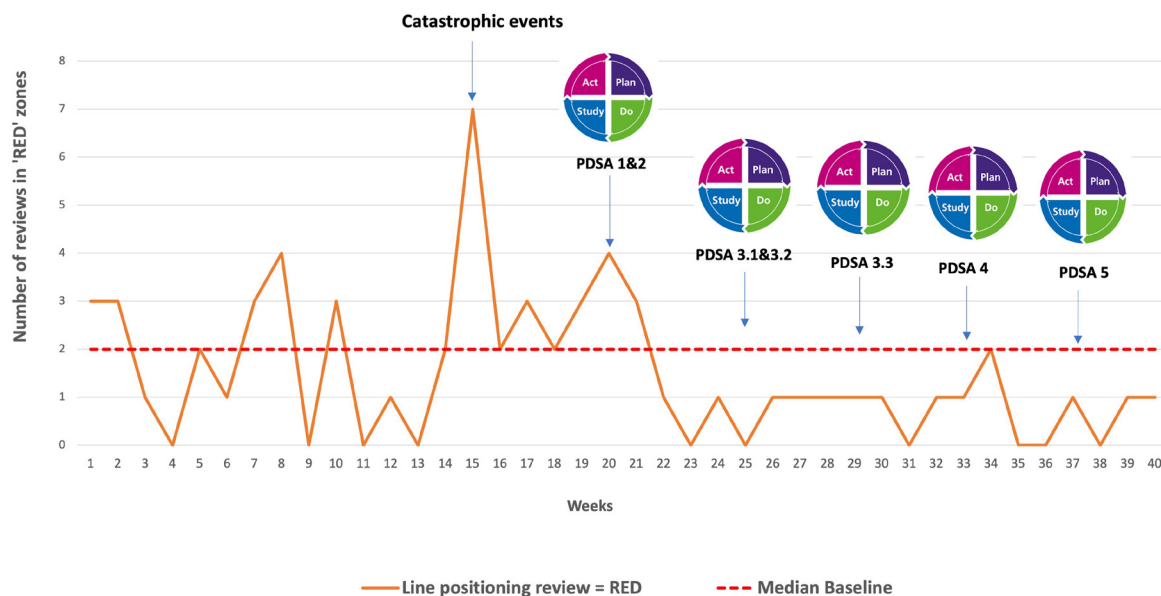
**Table 1** Summary of the five PDSA cycles

## INTERVENTIONS/IDEAS TO TEST

1. The issue was discussed in the local quality improvement (QI) meeting to raise awareness among staff members of all grades.
2. Improve radiology reporting to increase the timely identification of poorly placed lines.
3. Posters were designed to promote improvement actions. A CVC traffic light guide was created, along with illustrative reminders on the correct securing method of the catheter.
4. A new multidisciplinary radiology project was implemented to support the correct positioning of the limbs<sup>4,5</sup> and body of the baby before an X-ray was taken to check line positioning.
5. An education pack was brought together to support trainees of all levels of expertise.

PDSA	Plan	Do	Study	Act
<b>PDSA 1.1</b> Raise awareness (December 2021 to January 2022)	Awareness raised of the issue within the team	26 lines were reviewed. Colour coding showed 4/26 'red' lines (15.4%)	Improvement in 'red lines'—reduced by 12.1%. However, concerns remained regarding timely review of radiology reports and time of releasing	<b>ADOPT</b> Ward round proforma adjustments <b>IDEAS</b> 1. Check reports again retrospectively ( <b>ABANDON</b> ) 2. Improve interteam communication (Radiologists and Neonatologists—Later project) 3. Speed up radiology reporting ( <b>PDSA 2</b> )
<b>PDSA 1.2</b> Raise awareness (December 2021 to January 2022)	Ward round proforma changed to include 'review of the line tip'			
<b>PDSA 2</b> Improve radiology reporting (December 2021 to January 2022)	Neonatal team invited to implement some changes of their own	Senior team reviewed reports for short period of time—not sustainable. Some conversations took place with radiology. No detectable impact	Ideas not easily actionable and sustainable	<b>ABANDON</b>
<b>PDSA 3.1</b> Increased use of CVC traffic light system (January 2022- February 2022)	Posters to raise awareness of line positioning during X-ray ( <a href="#">figure 2</a> )	38 lines reviewed. Colour coding showed 3/38 'red lines' (7.8%)	Another significant improvement. Cumulative reduction in 'red lines' 19.7%.	<b>ADOPT</b> Illustrative posters <b>IDEAS</b> 1. Make Posters more widely available by uploading them on Neonatal Education website (Padlet) 2. Incorporate into unit's guidelines 3. Print and laminate posters. Place next to the main computers in all clinical areas ( <b>PDSA 3.3</b> )
<b>PDSA 3.2</b> Increased use of 'stepwise approach of PICC securing method'	Detailed illustration of the correct securing/dressing method of the catheter ( <a href="#">figure 3</a> )		Illustrative method of catheter tip securing and dressing was well received.	
<b>PDSA 3.3</b> Make posters more widely available (February 2022 to March 2022)	<ul style="list-style-type: none"> <li>▶ Place posters next to the main computers in all clinical areas</li> <li>▶ Add into unit guidelines</li> <li>▶ Add to the trust's electronic neonatal education website</li> </ul>	27 lines reviewed. Colour coding showed 4/27 'red lines' (14.8%)	A reduction in performance was subsequently noted (7% increase in 'red lines'). Rota gaps and new staff rotating were considered likely contributors	<b>ADOPT</b> <b>IDEAS</b> More ideas needed to reduce variation during rota changeovers 1. Optimise quality of X-rays as adversely affecting decision making ( <b>PDSA 4</b> ) 2. Education package ( <b>PDSA 5</b> )
<b>PDSA 4</b> Improved preparation and management of babies for X-ray (deficit ID during baseline data collection—March 2022 to April 2022)	Preparation optimised towards correct alignment of body and limbs. New 'Am I X-Ray ready' poster designed	42 lines reviewed. Colour coding showed 3/42 red lines (7.1%)	Percentage of red lines stabilised at 7%. Another reduction by approximately 8%	<b>ADOPT</b> Radiology department incorporated our work into their local education material.
<b>PDSA 5</b> New education package created and distributed to new rotation of doctors (April to May 2022)	Education package which included (1) vascular anatomical landmarks, (2) tips and hints of correct CVC insertion and monitoring of the line tip, (3) potential complications	44 lines reviewed. Colour coding showed 3/44 'red lines' (6.8%)	This change was found to be effective. However, feedback revealed that the CVC guide was quite long and not comprehensive	<b>ADOPT</b> Guide to be distributed in every new rotation of doctors. Future PDSA cycle planned to review effectiveness of planned changes <b>IDEA</b> 1. New team to create short explanatory videos
Further actions undertaken to support sustainability	<ul style="list-style-type: none"> <li>▶ Results presented locally, regionally and internationally to raise awareness</li> <li>▶ Main author became member of the working group of the regional neonatal CVC guidelines</li> <li>▶ Main author applied to BAPM to review national CVC guidelines and share local experience and QI work</li> <li>▶ Project handed over to subsequent teams and focused on improving the education package</li> <li>▶ Explore use of cyanoacrylate glue to secure lines more effectively</li> <li>▶ Feasibility of implementing point-of-care ultrasound</li> </ul>			

BAPM, British Association of Perinatal Medicine; CVC, central venous catheter; PICC, percutaneously inserted central catheter.



**Figure 3** Number of 'red' lines from July 2021 to April 2022. PDSA, plan-do-study-act.

The posters, particularly the 'Traffic light guide', optimised team engagement and communication and reduced inconsistency in line tip assessment by simplifying the procedure. The launch of the new X-ray project standardised factors that could create confusion when interpreting the catheter tip on an X-ray; among others (figure 2), we formalised limb position to '30° with shoulders abducted',<sup>4 5</sup> as suggested by national guidance 'perpendicular to the body' limb arrangement lead to misleading interpretation with catheters mainly appearing 'shorter' on initial X-rays.

Education and training were also important and extensively supported through this project. Finding an easy way to reliably provide a solid foundation for junior trainees embarking on their 'CVC journey' will help sustain our new and improved level of reliability. However, to achieve <5% (1 in 20) of malpositioned catheters is likely to require other process changes. The next step will be to test the use of cyanoacrylate glue<sup>6</sup> to secure lines more effectively. Further work will also be undertaken to determine the feasibility of implementing point-of-care ultrasound.<sup>7</sup>

This was a single-centre initiative. Determining the national picture would identify whether the problem exists beyond our neonatal unit. We now plan to liaise with other comparable units, share our findings and understand how they monitor their lines.

## KEY MESSAGES

The use of CVCs in neonatal care has the potential to cause significant harm.<sup>8</sup> Using scientifically informed improvement methodology, we have been able to gain a deeper understanding of the barriers to success, have clarity of aim, use defined measures to establish our baseline performance and track improvement, and use small-scale tests

of change (PDSA cycles) in series to establish the interventions that contribute to improvement in our unit and those that do not.

By combining these strategies, we have created a comprehensive approach to address the issue of malpositioned CVCs in neonatal care; early detection and intervention through our traffic light guide and ongoing education to prevent regression not only reduce the risk of harm but also promote a culture of safety within the healthcare system.

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**Contributors** OP conceived the original idea for the project and implemented it locally with ML under NJM's supervision. OP also performed data collection, analysis, and wrote the initial draft. ML contributed to data analysis and edited the initial draft alongside NJM. NJD evaluated the QI methodology and reviewed the final manuscript. NJM is the guarantor of the overall content.

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