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Retrospective cohort study of diagnosis–delivery interval with umbilical cord prolapse: the effect of team training

D Siassakos,[a] Z Hasafa,[b] T Sibanda,[c] R Fox,[d] F Donald,[e] C Winter,[f] T Draycott[g]

[a] Department of Obstetrics and Gynaecology, Southmead Hospital, and Medical Education, University of Bristol, Bristol, UK [b] Department of Obstetrics and Gynaecology, Southmead Hospital, Bristol, UK [c] Department of Obstetrics and Gynaecology, Southmead Hospital, Bristol, UK [d] Department of Obstetrics and Gynaecology, Taunton and Somerset Hospital, Bristol, UK [e] Department of Anaesthesia, Southmead Hospital, Bristol, UK [f] Southmead Hospital, Bristol, UK [g] Department of Obstetrics and Gynaecology, Southmead Hospital, Bristol, UK
Correspondence: D Siassakos, Research SpR in Obstetrics and Gynaecology, Southmead Hospital, and Clinical Lecturer (Hon) in Medical Education, University of Bristol, Bristol, UK. Email jsiasakos@gmail.com
Department: Women's Health, Chilterns, Southmead Hospital, Westbury on Trym, BS10 5NB

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Objective To determine whether the introduction of multi-professional simulation training was associated with improvements in the management of cord prolapse, in particular, the diagnosis–delivery interval (DDI).

Design Retrospective cohort study.

Setting Large tertiary maternity unit within a University Hospital in the United Kingdom.

Sample All cases of cord prolapse with informative case record: 34 pre-training, 28 post-training.

Methods Review of hospital notes and software system entries; comparison of quality of management for umbilical cord prolapse pre-training (1993–99) and post-training (2001–07).

Main outcome measures Diagnosis–delivery interval; proportion of caesarean section (CS) in whom actions were taken to reduce cord compression; type of anaesthesia for CS births; rate of low (<7) 5-minute Apgar scores; rate of admission to neonatal intensive care unit (NICU) (if birthweight >2500 g).

Results After training, there was a statistically significant reduction in median DDI from 25 to 14.5 minutes ($P < 0.001$). Post-training, there was also a statistically significant increase in the proportion of CS where recommended actions had been performed (from 34.78 to 82.35%, $P = 0.003$). There was a nonsignificant increase in the use of spinal anaesthesia for CS, from 8.70 to 17.65%, and a nonsignificant reduction in the rate of low Apgar scores from 6.45 to 0% and in the rate of admission to NICU from 38.46 to 22.22%.

Conclusions The introduction of annual training, in accordance with national recommendations, was associated with improved management of cord prolapse. Future studies could assess whether this improved management translates into better outcomes for babies and their mothers.

Keywords Medical simulation, obstetric emergencies, teamwork, training, umbilical cord prolapse.

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Introduction

At least one in twelve labours is associated with adverse events.[1] Confidential enquiries into poor outcomes have identified common teamwork errors: confusion about roles and responsibilities, failure to perform clinical tasks in a coordinated manner and poor communication.[2–7] Recommendations have included a widening of the focus of training to include team working as well as the development of clinical skills.

Effective team work training might be particularly important for sudden, unexpected, rare conditions that demand rapid coordinated response of a large multi-professional team. For example, cord prolapse, which complicates less than one in 200 labours[8–10] but is associated with an increased risk of neonatal hypoxic brain injury[8–10] and perinatal death.[5–7,9,10] National recommendations state that preparations should be made for delivery in theatre within 30 minutes, usually by caesarean section urgency category 1, without unduly risking

maternal safety.[8–10] In the interim, specific manoeuvres should be used to alleviate compression on the cord and reduce the chance of fetal hypoxia-acidosis. Several studies have identified delay in transfer to theatre as the main factor associated with prolonged decision-delivery intervals in emergency caesarean births.[11–15] The proportion of staff receiving annual training in the management of cord prolapse and the mean decision-delivery interval, in actual cases of cord prolapse, are now auditable standards.[10,16–18]

The aim of this study was to determine whether the introduction of annual training improved management of cord prolapse, with particular reference to diagnosis–delivery interval as an indicator of effective teamwork. A secondary objective was to determine whether the introduction of training was associated with improvements in compliance with other key recommendations (use of methods to reduce pressure on cord, use of regional anaesthesia where appropriate) and in measures of neonatal outcome.

Methods

Study design

A retrospective cohort observational study.

Setting

A maternity unit in the South West of England, caring for 5000–6000 births per annum. The management and neonatal outcome of hospital births complicated by cord prolapse was retrieved before and after the introduction of annual training. Case records were analysed from two seven-calendar-year periods; pre-training (1993–99) and post-training (2001–07). The first intervention year (2000) was excluded from the analysis.

Data collection

Using a UK-based maternity database (STORK), births complicated by umbilical cord prolapse were identified and the hospital case records were retrieved. The diagnosis was confirmed by case note review. Eligible cases were those in which the prolapsed cord had been clearly seen or palpated below the presenting part by a senior obstetrician (registrar or consultant). Cases of home birth or cord prolapse with a second twin were excluded. Cases in which the medical record was missing or uninformative were also excluded. A preformatted checklist was used to retrieve data.

The diagnosis–delivery interval was derived from case note entries and cross-checked against the operating notes and the anaesthetic records. In all cases where the exact decision-to-deliver time had been documented, it coincided with the time of diagnosis.

Training intervention

In 2000, a multi-professional group comprising midwives, obstetricians and anaesthetists, developed an obstetric emergency training intervention. Training consists of a 1-day course that is held every 2 months to accommodate all midwifery and obstetric medical staff. Annual attendance is mandatory and is recorded on a database. All staff use one of their allocated study days. New members of staff are required to attend the next available course and an end of year course is run for those who have failed to attend in the preceding year. Non-attendees are identified using the database as well as trainee annual assessments, consultant appraisals and midwives' supervision schemes. Annual attendance has ranged from 95 to 100%.

All course materials have been developed in-house by a multi-professional steering group and are regularly updated. The drills are based on principles informed by the results of a multi-centre random-allocation trial funded by the UK Department of Health Patient Safety Research Programme (the *SaFE* Study).

During the drills, participants work in their normal work roles on their labour ward. This is followed by structured feedback focussing on clinical, teamwork and communication aspects of care, using standardised checklists. Patient-actors, trained members of staff with specific instructions on how to behave during the simulation, are used for many drills. At the end of the rehearsal, they feed back to the participants whether they felt safe, respected and satisfied with communication, using a simple validated scale.[19–22]

Included in the training day is a station, with a patient-actor, on management of cord prolapse. The drill covers all aspects of clinical management and communication during the emergency, including announcement of the nature and urgency of the case, informed consent and detailed contemporaneous documentation. The equipment used includes a cushion to imitate a pregnant abdomen, a model of a baby with its umbilical cord, a mock perineum from a disused episiotomy trainer, venous cannulae with needles removed, syringes, bladder-filling equipment, case notes and terbutaline ampoules. The drill is usually run in a labour room and is stopped when teams decide to move the woman to theatre for a caesarean section of urgency category 1. The scenario enables staff to practice transferring a delivery bed and patient in an emergency situation.

The objective of the rehearsal is to teach participants to: recognise the risk factors for cord prolapse; call for appropriate assistance; perform manoeuvres to reduce pressure on the cord; communicate effectively with the woman; take detailed contemporaneous documentation. After the rehearsal, feedback focuses on: identification of cord prolapse; consideration of methods for *in-utero* resuscitation; preparation for transfer to theatre for delivery. Emphasis is

also placed on the communication required between all members of the multi-professional team when an emergency caesarean section is necessary. Discussions include the classification of caesarean section into urgency categories 1, 2, 3 and 4, and the issue of consent during emergencies.

Sample size

Sample size was derived pragmatically. With annual births averaging 5500 and an incidence rate of approximately 0.1–0.2%,[10] it was anticipated that there would have been five to ten cord prolapse cases per year and that it would be possible to retrieve good data from about 70% of them. It was calculated that there would be 28 to 56 case records for each cohort (7 years × 70% retrieval × 0.1–0.2% incidence × 5500 births per annum).

Outcome measures

Data were collected on primary and secondary outcome measures: diagnosis-to-delivery interval, 5-minute low (<7) Apgar score rate, rate of admission to the neonatal intensive care unit for neonates weighing more than 2500 g and stillbirth rate. Data were collected on variables that had either potentially confounding effects or were relevant to safety and quality of care: use of manoeuvres to reduce cord compression (elevating presenting part, filling maternal bladder, maternal positioning), presence or absence of fetal bradycardia, gestational age in completed weeks, birthweight in grams.

Statistical analysis

Data were put into Excel files and cross-checked by two researchers. Statistical analysis was undertaken using STATA software version 8.0 (StataCorp, College Station, TX, USA). Mann–Whitney *U* test was used to compare time intervals. The Fisher's exact test was used to analyse differences in the proportion of manoeuvres used, which alleviate cord compression, between the two cohorts. To decrease the effect of confounding variables, the analysis was repeated after excluding cases where there had been no fetal bradycardia at diagnosis. The Fisher's exact test was used to analyse the proportion of cases where DDI was <30 minutes before and after training (an internationally accepted cut-off for category 1 obstetric emergencies).

We obtained permission by our Clinical Audit and Effectiveness Department of Clinical Governance at North Bristol NHS Trust, Protocol ID number 884. We followed the STROBE[23] guidelines and checklist to report the study.

Results

We identified 56 women who suffered cord prolapse in the first group (pre-training) and 38 in the second group (post-training), an incidence of 0.15 and 0.11% respectively. Complete information on outcome measures was available for 34 (61%) in the first group and 28 (74%) in the second. More notes were incomplete before 2000: three did not have clear documentation of fetal heart rate pattern after diagnosis and one did not have clear documentation of birthweight; after 2000, the relevant figures were zero and one respectively.

Descriptive (case-mix) characteristics were similar for the two groups: median (mean, SD) gestational age, in completed weeks, was 38 (36.1, 5.6) pre-training and 38 (36.2, 5.6) post-training; median (mean, SD) birthweight in grams was 3230 (2944, 1047) pre- and 3020 (2865, 1176) post-training. The mode of birth was [pre-training *n*(%)/post-training *n*(%)]: forceps/ventouse 6 (18.18%)/5 (19.23%); spontaneous cephalic vaginal 3 (9.09%)/2 (7.69%); assisted breech vaginal 1 (3.03%)/2 (7.69%); caesarean section 23 (69.90%)/17 (65.39%).

There was one case with 340-minutes DDI pre-training, where the woman had chosen expectant management for a fetus of 24 weeks gestational age and 642 g birthweight. This case was excluded from further analysis. There were two cases with very short DDI post-training, where cord prolapse occurred for the second twin. These were also excluded from further analysis. Our final cohorts consisted of 33 women pre-training and 26 women post-training.

Training was associated with a statistically significant decrease in the median diagnosis-to-delivery interval from 25 to 14.5 minutes ($P < 0.001$, Mann–Whitney *U* test). Figure 1 demonstrates the progress recorded for our median DDI over time, against the national standard of <30 minutes.[24] Figures 2 and 3 illustrate the distribution and scatter of the DDI respectively.

Post-training, women were more likely to receive spinal anaesthesia than general anaesthesia for urgency category 1 caesarean birth (Table 1). The difference would be clinically important, but it was not statistically significant.

More cases post-training had fetal bradycardia at diagnosis (21, 80.77%) compared to cases pre-training (19, 63.33%). We therefore performed a sub-analysis of those women with a fetal bradycardia. Training was still associated with a statistically significant decrease in the percentage of cases with DDI of more than 30 minutes from 6 (31.58%) of 19 pre-training to none of 21 post-training ($P = 0.007$, Fisher's exact). For these women with fetal bradycardia, the median DDI improved from 25 minutes pre-2000 to 14 minutes post-2000.

Of cases without fetal bradycardia, two post-training had a DDI of more than 30 minutes. In both of them, there was no suspicion of fetal distress; 5-minute Apgar scores were 9; 10-minute Apgar scores were 10 and venous pH at

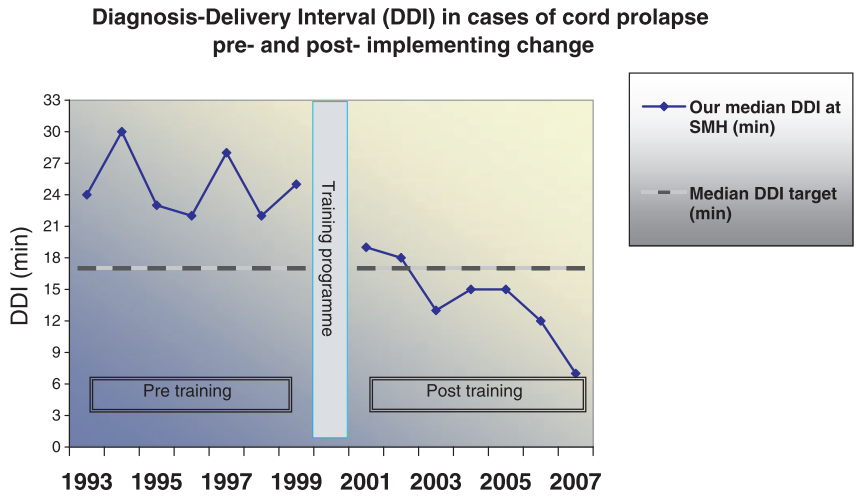

Figure 1. Quality improvement (*run*) chart demonstrating the progress over time of the median DDI for cord prolapse in comparison with the UK national median DDI[24].

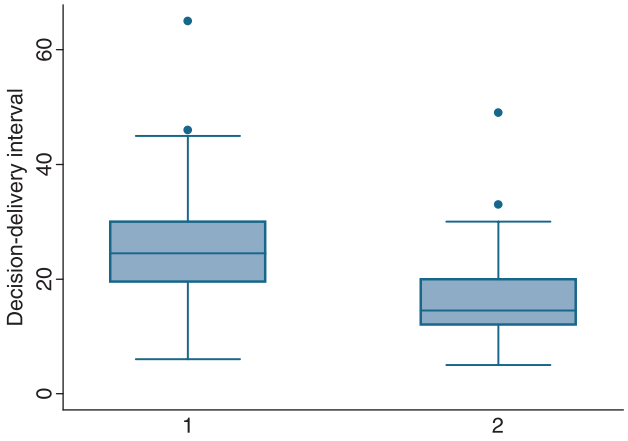

Figure 2. Box-and-whisker plot showing the distribution and spread of DDI before and after training (diagnosis–delivery interval used as proxy for decision-delivery interval).

delivery was more than 7.25. One neonate was born at term and did not need any special neonatal care, the other one was born at 35 completed weeks and was admitted to our neonatal unit for routine observation (for five days), without any recorded complications.

There was a significant increase in use of recommended actions to alleviate cord compression post-training: 14 cases (82.35%) had at least one action to reduce cord compression while preparing for CS, compared with eight (34.78%) pre-training ($P = 0.003$, Fisher's exact). The details for individual recommendations are given in Table 2.

All measures of neonatal outcome improved post-training, but the difference was not statistically significant (Table 1).

Discussion

Key results

The introduction of a multi-professional obstetric emergency training course was associated with a significant reduction in median DDI and a nonsignificant improvement in neonatal outcome measures. In addition, for caesarean births, there was a statistically and clinically significant increase in the use of recommended manoeuvres and a nonsignificant increase in the use of spinal anaesthesia. For cases with bradycardia, there was a statistically significant increase in the proportion of babies delivered within the 30-minute DDI limit, to 100% post-training.

Limitations

Our study is observational and thus prone to the influence of confounding factors. Pragmatic issues necessitate the use of historical controls. Cord prolapse is an extreme emergency and therefore unsuitable for a controlled trial in a single centre. A cluster design randomised-controlled trial of training would necessitate multicentre involvement. This would render the results open to confounding by local interventions and other factors. Moreover, withholding training for some units (controls) could be unethical. A stepped-wedge trial, where units are randomly allocated the order in which they receive training, would need even larger samples and a longer observation period.[25]

A possible confounding variable is that the course was designed to fulfil all the requirements for a public insurance scheme for acute hospitals (CNST—Clinical Negligence Scheme for Trusts).[16] The multiple clinical governance interventions and organisational changes associated with that programme of risk management could have played a

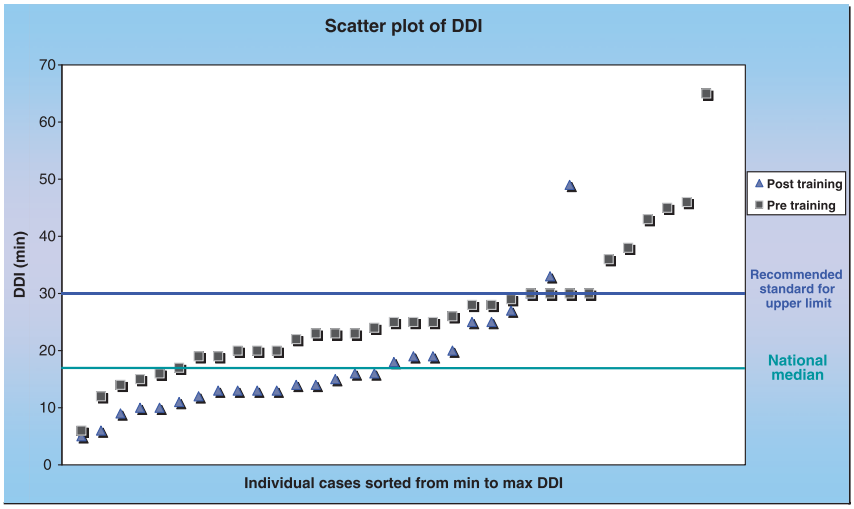

Figure 3. Scatter plot of DDI before and after training in relation to the UK national median DDI[24] and the recommended upper DDI cut-off[10].

Table 1. Additional management and outcome data

Variable	Pre-training	Post-training	*P*-value (Fisher's exact)
Regional (spinal) anaesthesia for caesarean section (CS) births *N* (% of CS)	2 (8.70)	3 (17.65)	*P* = 0.354
Admissions to neonatal care unit *N* (% of liveborn >2500 g)	10 (38.46)	4 (22.22)	*P* = 0.210
5-minute Apgar score<7 *N* (% of liveborn)	2 (6.45)	0	*P* = 0.302
Stillbirth *N* (% of total)	2 (6.06)	1 (3.85)	*P* = 0.590

Table 2. Use of recommended actions to reduce cord compression (*stabilising)* while preparing for caesarean section, pre- and post-training (vaginal births excluded)

Action	Pre-training *N* (%)	Post-training *N* (%)	*P*-value (Fisher's exact)
Elevating the presenting part	5 (21.74)	7 (41.18)	*P* = 0.164
Adopting the knee-chest & head-down position	3 (13.04)	5 (29.41)	*P* = 0.189
Filling the bladder	0	1 (5.88)	*P* = 0.425
Tocolysis	0	1 (5.88)	*P* = 0.425
At least one action documented	8 (34.78)	14 (82.35)	*P* = 0.003
No stabilising action documented	15 (65.22)	3 (17.65)	
Total CS	23	17	

role in improving outcomes. However, our objective was not to consider training as an intervention in isolation, but in the context of a wider agenda for quality improvement. A recent large multicentre randomised-controlled trial of Crew Resource Management (CRM) teamwork training failed to demonstrate any improvement in outcomes.[1] However, when the training was supplemented with local safety interventions, outcomes improved.[26]

Another limitation of our study, common to retrospective observational designs, is that the validity of the results is adversely affected by the availability and accuracy of the information available, often many years after events occurred. We observed better documentation after 2000. It is highly unlikely that the DDI, anaesthetic and neonatal data were affected by this, but there remains a possibility that other aspects of management were performed but not documented before 2000. One of the aims of training was to improve documentation and it is interesting that it improved post-2000. It is evident, however, that there is still room for improvement. Of note, a recent review of 189 closed perinatal claims concluded that a safety strategy including better documentation by use of standardised proformas might help prevent more than half of hospital litigation costs.[27]

Case-mix can affect results of observational studies. In this study, even though the case-mix was broadly similar for the two cohorts, there were more cases with bradycardia post-training. Fetal bradycardia is likely to urge maternity teams to deliver faster than situations without bradycardia.

Therefore, we performed a sub-analysis of bradycardia cases alone. All such cases were delivered within 30 minutes from diagnosis post-2000, whereas this was achieved for about one in three cases with fetal bradycardia pre-2000. The difference from pre-training was both statistically and clinically significant; compliance with the recommended auditable standard[10] improved from 68.42 to 100%.

International acknowledgement of the 30-minute target might have been responsible for the improvement. Nevertheless, many recent studies have demonstrated unequivocally that simple awareness of the target does not result in improvement. Local training and quality improvement initiatives are necessary for compliance with standards.[13,14,28–32]

We used diagnosis–delivery interval rather than decision-delivery interval for this study as actions between diagnosis and decision form an important component in care. In reality, in most cases, the time of diagnosis and decision coincided, as expected for such an emergency.

Finally, we note that the percentage of babies delivered by forceps or ventouse is high in our study (about 18% pre-2000 and about 19% post-2000). We acknowledge that in other countries women with cord prolapse might be less likely to be offered the option of assisted vaginal delivery. However, in the UK, the national guideline for management of cord prolapse recommends that operative vaginal birth can be attempted at full dilatation if it is anticipated that delivery would be accomplished safely.[10]

Interpretation

National enquiries have identified an obvious need for improved teamwork in obstetrics.[2,4,7] Isolated teamwork interventions based on aviation theory have not been associated with improvements in outcome.[1] However, the *SaFE* study in the UK demonstrated improved team behaviour and markers of clinical care after clinical training in teams. Extra teamwork training based on a CRM model did not confer any additional benefit.[33] It seems that training as a team improves team working.

This study provides further evidence that team training with rehearsal of obstetric emergencies results in improved clinical outcomes as well as in performance in simulation. Local training provides the opportunity for teams to identify local safety problems that can be addressed with targeted interventions. In our unit, the patient bed could not pass through the door in two labour rooms, resulting in delays while a trolley was brought in. This was identified during some of the early rehearsals and the door frame has now been widened.

Monitoring diagnosis-to-delivery intervals remains important in evaluating quality and safety of maternity care.[34] The generally accepted standard for CS of urgency category 1 in the United Kingdom and elsewhere is 30 minutes.[35] Guidelines for management of cord prolapse have confirmed that this remains the target.[10] Despite these recommendations, the 30-minute DDI remains an elusive target in many maternity units around the world.[13,14,28–32]

The improved results in our unit do not seem to be a result of more frequent use of general anaesthesia (GA). On the contrary, we were able to use spinal anaesthesia for about one in five women who needed CS of urgency category 1 after 2000, as compared with about one in 12 before 2000. Conducting emergency CS with spinal anaesthetic can take more time than GA[36] but, particularly in the emergency setting, regional anaesthesia remains safer than general for mothers and possibly babies.[37,38] The literature suggests that the main reason why units fail to comply with the 30-minute target for category 1 CS is the transfer time to theatre.[11,12,39] This represents approximately half of the total DDI.[11] When this transfer time is reduced as a result of better team communication, total DDI can be shorter, but there is also time for placement of regional anaesthesia. Use of appropriate manoeuvres to reduce cord compression also helps to make regional anaesthesia an option by reducing the chance of fetal heart rate abnormalities.[10] Following training, these were used more reliably.

Measures of neonatal outcome improved after training, but the difference did not reach statistical significance; we acknowledge that unrealistically large samples would be necessary. The fact that there was no deterioration in outcome is reassuring; shorter decision-delivery intervals for emergency CS births have been associated with worse outcomes in the literature,[29,40] possibly because more extreme cases get delivered more quickly. On the contrary, similar or improved neonatal outcomes in our study suggest that improved management, including better team communication, was responsible for the reduction in DDI rather than different case-mix. The finding that cases with fetal bradycardia were delivered sooner post-training compared to pre-training, is further evidence of this.

Another possible benefit of improved team coordination is that it could reduce the risk of mothers' psychological trauma; the latter has been associated with poor communication within the team and with mothers, birth partners and relatives.[41–47] However, the SaFE study demonstrated that patient-actor perception of safety, communication and respect during simulated obstetric emergencies improved after team training, concurrently with improvements in team communication.[19,48] We propose that maternal satisfaction after real-life emergencies should be formally tested with validated tools in future studies.

Conclusion

The findings of this study provide further evidence that multi-professional team simulation training for obstetric

emergencies is associated with improved compliance with national standards, probably through a combination of improved clinical knowledge and better team working. A multicentre random-allocation trial of clinical training is now needed to prove a difference in real-life outcomes, focussing on more common emergencies, such as postpartum haemorrhage and shoulder dystocia. Babies and their mothers merit this investment.

Disclosure of interests

Mr Draycott, Dr Donald and Ms Winter are members of the steering committee of PROMPT, a UK-based charity running training courses and have no financial interest from this association.

Contribution to authorship

D Siassakos conceived idea, designed study, conducted subanalyses, performed literature review, authored manuscript. Z Hasafa conducted study and collected data, co-authored manuscript. T Sibanda helped designed study, conducted statistical analysis, co-authored manuscript. R Fox refined study methodology and subgroup analyses, supervised the transparent reporting of results, co-authored and edited manuscript. F Donald authored anaesthetic considerations, edited manuscript. C Winter coordinated training intervention, authored midwifery considerations, edited manuscript. T Draycott coordinated training intervention, supervised study, co-authored and edited manuscript.

Details of ethics approval

The analysis was conducted in 2008 as a retrospective evaluation of the existing service within the Clinical Audit and Effectiveness/Service Evaluation Framework of Clinical Governance at North Bristol NHS Trust, Approval ID 884.

Previous presentations

Some of the results described in this manuscript have been presented as abstracts at the International Medical Simulation of the Society for Simulation in Healthcare (Florida, January 2009: Best Research Abstract—Overall winner) and the 14th Annual International Scientific Symposium on Improving the Quality and Value of Health Care of the Academy of Health Improvement (Nashville, Tennessee, December 2008: Oral Presentation).

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