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Prevention of brachial plexus injury—12 years of shoulder dystocia training: an interrupted time-series study

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Objective To investigate management and outcomes of incidences of shoulder dystocia in the 12 years following the introduction of an obstetric emergencies training programme.

Design Interrupted time-series study comparing management and neonatal outcome of births complicated by shoulder dystocia over three 4-year periods: (i) Pre-training (1996–99), (ii) Early training (2001–04), and (iii) Late training (2009–12).

Setting Southmead Hospital, Bristol, UK, with approximately 6000 births per annum.

Population Infants and their mothers who experienced shoulder dystocia.

Method A bi-monthly multi-professional 1-day intrapartum emergencies training course, that included a 30-minute practical session on shoulder dystocia management, commenced in 2000.

Main Outcomes Neonatal morbidity (brachial plexus injury, humeral fracture, clavicular fracture, 5-minute Apgar score <7) and documented management of shoulder dystocia (resolution manoeuvres performed, traction applied, head-to-body delivery interval).

Results Compliance with national guidance improved with continued training. At least one recognised resolution manoeuvre was used in 99.8% (561/562) of cases of shoulder dystocia in the late training period, demonstrating a continued improvement from 46.3% (150/324, $P < 0.001$) pre-training, and 92% (241/262, $P < 0.001$) in the early training period. In parallel there was reduction in the brachial plexus injury at birth (24/324 [7.4%, $P < 0.01$], pre-training, 6/262 [2.3%] early training, and 7/562 [1.3%] late training.

Conclusions There are significant benefits to long-term, embedded training programmes with improvements in both management and outcomes. A decade after the introduction of training there were no cases of brachial plexus injury lasting over 12 months in 562 cases of shoulder dystocia.

Keywords Brachial plexus injury, shoulder dystocia, simulation, training.

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Introduction

Shoulder dystocia remains a largely unpredictable event in which the fetal shoulders are trapped above the inlet to the maternal pelvis, hindering delivery of the baby[1,2] and which can result in serious long-term morbidity for both mother and baby. Current international guidance[3,4] recommends four basic shoulder dystocia resolution manoeuvres (McRoberts' position, suprapubic pressure, delivery of the posterior arm and internal rotation).

Brachial plexus injury is the most frequent serious neonatal morbidity associated with shoulder dystocia. The incidence varies substantially between studies (2–16% of births complicated by shoulder dystocia[5–8]) suggesting that at least some of these injuries might be preventable.[8] Aside from any personal harm and health costs, poor outcomes can result in very significant litigation costs. In the USA shoulder dystocia is the second most commonly litigated complication of childbirth,[9] and in England, the NHS Litigation Authority paid more than £100 million in legal compensation over a decade for preventable harm associated with shoulder dystocia.[10]

Shoulder dystocia training has been recommended since 1998[11] but until recently there has been no clear evidence

on the best method of training. Some shoulder dystocia training has been demonstrated to improve knowledge,[12] confidence[13] and management of simulated shoulder dystocia.[14–17] However, the effect of training on perinatal outcomes has been conflicting; there are reports of improvements after training,[8,18,19] whereas other training has been associated with no change in outcomes,[20] or even an increase in poor neonatal outcomes after training had been introduced.[21] Practice does not make perfect if it is the wrong practice.

The objective of this study was to investigate the long-term effect of evidence-based shoulder dystocia training on the management of, and neonatal outcomes following, shoulder dystocia.[8]

Methods

A multi-professional 1-day intrapartum emergencies training course was established at Southmead Hospital, North Bristol NHS Trust, Bristol, UK, in April 2000.[22] All midwifery and obstetric medical staff are contractually mandated to attend annually. Every training day held since 2000 has included a 30-minute practical session on shoulder dystocia management using the PROMPT Birthing Trainer (Limbs and Things Ltd, Bristol, UK) and incorporating lessons from previous simulation-based studies.[3,15,23–25] Each session is facilitated by a midwife and/or an obstetrician and attended by a multi-professional team of five to eight members of staff. At the start of each session the trainers demonstrate the bony impaction of shoulder dystocia using the mannequin with the abdominal skin removed and discuss the importance of routine traction 'do not pull hard, do not pull quickly and do not pull down'. Each member of staff then takes it in turn to practice each shoulder dystocia resolution manoeuvre (McRoberts', suprapubic pressure, delivery of the posterior arm and internal rotation) before the team runs through a simulated shoulder dystocia scenario. Previously, we reported that implementation of this training was associated with a significant reduction in neonatal injury at births complicated by shoulder dystocia; 9.3% pre-training to 2.3% in the 4 years post-training.[8] A shoulder dystocia documentation pro forma was introduced into the department in July 2003.

This new retrospective observational study (of prospectively collated data) compared our previously reported outcome data with a further 'late training' implementation period to investigate whether these improvements had continued or decayed over time:

1 Pre-training (1 January 1996 to 31 December 1999).
2 Early training implementation (1 January 2001 to 31 December 2004).
3 Late training implementation (1 January 2009 to 31 December 2012).

The methodology employed for the 1996–04 analysis has previously been described[8] and the same methodology was used for the third time period (2009–12) reported in this paper.

All infants born under the care of North Bristol NHS Trust (NBT) during the three time periods were identified using two standard UK-based maternity databases; STORK (all births before 1 September 2010) and Euroking (all births after 31 August 2010). Labour and delivery details of every birth occurring at NBT were entered directly onto the maternity database immediately following each birth. Difficulty with birth of the shoulders/shoulder dystocia was a mandatory field in both electronic clinical databases. Infants were excluded from analysis if they had been born by caesarean section, vaginal breech birth, were preterm (<37 weeks of gestation), if there was a multiple pregnancy, or if fetal death had been confirmed before delivery. Maternal notes in which 'difficulty with the shoulders' had been recorded on the STORK maternity database, or 'shoulder dystocia' had been recorded on the Euroking and/or Maternity Risk Management databases were obtained from the medical records department.

Maternal intrapartum notes were reviewed for evidence of shoulder dystocia (shoulder dystocia, tight/difficult shoulders, traction, additional manoeuvres used) by an obstetrician (JC, GB, ST, HC). Shoulder dystocia was defined using the Royal College of Obstetricians and Gynaecologists definition: a vaginal cephalic delivery that requires additional obstetric manoeuvres to deliver the fetus after the head has delivered and gentle traction has failed.[3] When shoulder dystocia was confirmed, data regarding the management of shoulder dystocia (listed in Table 1) were collected using a maternal pro forma that had been previously designed and pretested on a small number of case records. A research obstetrician (JC, GB, ST, HC) retrospectively reviewed the maternal intrapartum and postpartum medical notes for any evidence of suspected neonatal injury (decreased arm movement, suspected fracture, other). If there was no harm identified and that was clearly documented by the neonatologist in the time after birth in the maternity record, and there was no mention of postnatal problems by the community midwife until discharge to Health Visitor care at day 10 of life then no injury was assumed. An independent neonatologist reviewed the neonatal notes, if (i) nothing had been written in the maternal notes about the neonatal condition, or (ii) if there was anything to suggest neonatal injury in the maternal notes. Details of any neonatal injury were recorded (injury and duration) using a standardised neonatal *pro forma*. The neonatal notes were not reviewed if it was clearly and unequivocally recorded that there were no signs of injury/harm to the baby. The NBT Maternity

Table 1. Characteristics of eligible births according to training period

	Pre-training (1996–99) (*n* = 15 908)	Early training (2001–04) (*n* = 13 117)	Late training (2009–12) (*n* = 17 037)
Confirmed shoulder dystocia, *n* (%)	324 (2.04)	262 (2.00)	562 (3.30)***
Maternal age (years), mean (SD)	28.6 (5.3)***	29.1 (5.8)	29.4 (5.7)***
Nulliparous, *n* (%)	6667 (41.91)***	5879 (44.82)	8162 (47.9)***
Obese**** (BMI ≥30 kg/m^2), *n* (%)	1495 (10.2)***	1613 (12.9)	2320 (16.0)***
Morbidly obese**** (BMI ≥40 kg/m^2), *n* (%)	117 (0.8)***	162 (1.3)	263 (1.8)**
Maternal diabetes mellitus, *n* (%)	63 (0.4)*	74 (0.6)	184 (1.1)***
Labour induced, *n* (%)	3374 (21.2)***	3018 (23.0)	3823 (22.4)
Instrumental delivery, *n* (%)	2400 (15.1)*	2104 (16.0)	3059 (18)***
Gestational age (weeks), mean (SD)	39.8 (1.1)	39.8 (1.2)	39.8 (1.1)
Birthweight***** (g), mean (SD)	3457 (475)**	3442 (478)	3482 (469)***
Birthweight ≥4000 g, *n* (%)	2064 (13.0)	1636 (12.5)	2297 (13.5)**
Birthweight ≥4500 g, *n* (%)	264 (1.7)	222 (1.7)	311 (1.8)
Male, *n* (%)	8168 (51.35)	6626 (50.51)	8669 (50.9)

Group comparisons were conducted with a modified Poisson regression except for Maternal age, Gestational age and Birthweight, which were compared using a linear regression.
Statistically significantly different from post-training period *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
****Missing values pre-training 1220, early training 644, late training 2487.
*****Missing values pre-training 21, early training 15, late training 54.

Risk Management and Physiotherapy databases were cross-checked for any missing cases.

The findings are reported by time-period. Poisson regressions with a robust error variance were used to compare the proportions by time period using the immediate post-training period as the reference time. This modified Poisson regression approach is preferred to logistic regression in a context of non-rare outcomes. Linear regressions or Kruskal–Wallis tests were used to compare continuous characteristics. A 5% level of significance was used throughout. Analyses were conducted with STATA (version IC 13.1; StataCorp, College Station, TX, USA). Ethics committee approval was obtained from the Hampshire A Research Ethics Committee (13/SC/0570).

Results

Between 2009 and 2012, 91.1% of eligible staff members were trained (Table S1). Each member of staff managed a simulated shoulder dystocia scenario on each occasion that they attended training. The staff of NBT managed 20 635 births during the pre-training period, 18 585 births during the early training period and 24 622 births during the late training period, of which 15 908 (77.09%), 13 117 (70.58%) and 17 037 (69.19%) met the eligibility criteria, respectively. Figure 1 reports details of the births and exclusions. The proportion of infants born by elective and emergency caesarean section was higher in the post-training period (Figure 1).

'Difficulty with the shoulders' or 'shoulder dystocia' was recorded in 402 (2.53%) of eligible births pre-training, 318 (2.42%) immediately post-training and 570 (3.35%) in the late training period. Of these, maternal notes were available for review in 359 (89.3%), 280 (88.1%) and 565 (99.1%), respectively. Of the notes reviewed, shoulder dystocia was confirmed in 324 (90.3%) pre-training, 262 (93.6%) immediately post-training and 562 (99.5%) in the late training period.

There was a statistically significant increase in the proportion of births with confirmed shoulder dystocia in the time period 2009–12, compared with births occurring in 1996–99 and 2001–04 (Table 1). Women giving birth vaginally between 2009 and 2012 were more likely to be nulliparous, older, diabetic and obese, or morbidly obese, than those who gave birth between 2001 and 2004. Babies were heavier and more likely to have been born by operative vaginal delivery (Table 1). Women whose delivery was complicated by shoulder dystocia in the late training period (2009–12) were more likely to have been nulliparous and to have had an operative vaginal birth than those who had a shoulder dystocia before (1996–99) or immediately after (2001–04) training was introduced. There was no statistically significant difference in the incidence of maternal diabetes mellitus, gestational age at birth, or the rate of induced labour between the study periods (Table S2). The proportion of births complicated by shoulder dystocia that were completed by an obstetric trainee or consultant was higher in the late training period, in parallel with the increased rate of instrumental deliveries.

The management of shoulder dystocia continued to improve since the introduction of training at NBT in the

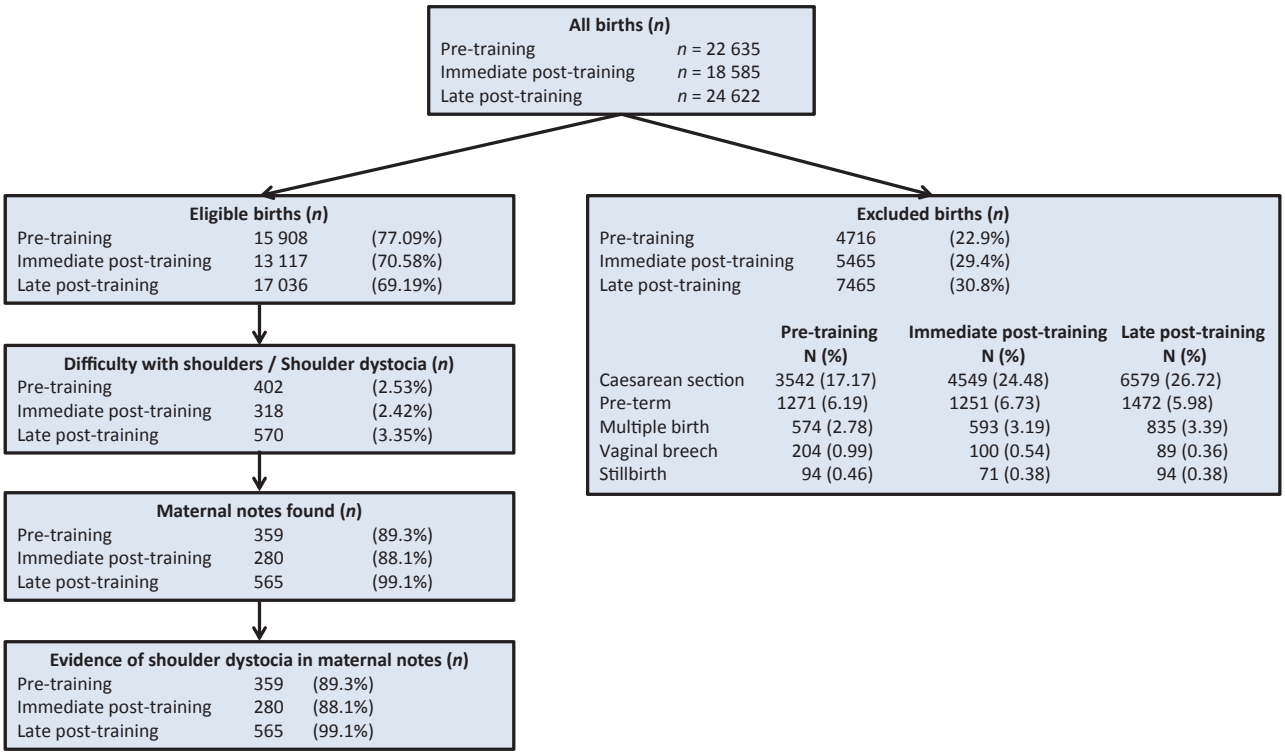

Figure 1. Eligible births and cases of shoulder dystocia.

year 2000 (Table 2). Appropriate manoeuvres (McRoberts', suprapubic pressure, internal rotation and delivery of the posterior arm) were performed more frequently, and incorrect actions (fundal pressure, lithotomy, left lateral, excessive traction) were used less often in the late training period (2009–12), than before training, and in the early training period. A decade after annual training had been introduced at least one recommended manoeuvre was used in over 99% of cases of shoulder dystocia managed by NBT staff.

The documentation of shoulder dystocia management also improved. In the late training period (2009–12), the head-to-body delivery interval was documented in 97.3% cases, compared with 26.5% before training, and 59.9% early after the introduction of training (Table 2). Furthermore, the fetal position during the dystocia was documented in 75.3% cases in the late training period, compared with 6.3% before training, and 22.1% early after the implementation of training.

Between 2009 and 2012 there were no permanent cases of brachial palsy injury (BPI) (an injury still present at 12 months, or any injury requiring operative intervention) in 562 cases of shoulder dystocia (Table 3). This compares with the pre-training and early training permanent injury rates of 1.9 and 0.8%, respectively. In parallel, there was also a fall in the proportion of shoulder dystocia cases in which the baby sustained a fractured humerus or clavicle, or had an Apgar score of less than seven at 5 minutes, although absolute numbers were small and therefore statistical interpretation is difficult.

Discussion

Main findings

This study has reviewed the management and outcomes of 1148 cases of shoulder dystocia cared for within a single UK healthcare institution, now more than a decade after the introduction of training. The proportion of staff trained annually was consistently very high (>85%). The risk factors for, and incidence of, shoulder dystocia had increased in the latest cohort, but the rate of morbidity associated with shoulder dystocia had continued to fall. Twelve years after the introduction of training for all maternity staff, compliance with national standards was sustained and the fetal morbidity associated with shoulder dystocia was extremely low with no cases of permanent BPI in the last 4 years of the follow up, involving more than 17 000 vaginal births.

Strengths and limitations

An increased caesarean section rate could have contributed to the reduction in injury following shoulder dystocia if

Table 2. Comparison of shoulder dystocia management before and after introduction of training

	Pre-training (1996–99) (*n* = 324)	Early training (2001–04) (*n* = 262)	Late training (2009–12) (*n* = 564)
McRoberts' position performed, *n* (%)	95 (29.3)***	229 (87.4)	560 (99.6)***
Suprapubic pressure applied, *n* (%)	90 (27.8)***	120 (45.8)	339 (60.3)***
Posterior arm extraction performed, *n* (%)	24 (7.4)***	52 (19.9)	189 (33.6)***
Internal rotational manoeuvre performed, *n* (%)	23 (7.1)	29 (11.1)	80 (14.2%)
No recommended manoeuvres performed, *n* (%)	174 (53.7)***	21 (8.0)	1 (0.2)***
Fundal pressure applied, *n* (%)	5 (1.5)*	0 (0.0)	2 (0.4)*
Lithotomy or lateral positioning, *n* (%)	20 (6.2)***	3 (1.2)	3 (0.5)
Excessive traction documented, *n* (%)	54 (16.7)*	24 (9.2)	2 (0.4)***
Head-to-body delivery time documented, *n* (%)	86 (26.5)***	157 (59.9)	547 (97.3)***
Head-to-body delivery time (minutes), median (25th, 75th centiles)	3 minutes* (2, 4) *n* = 86	2 minutes (2, 3) *n* = 157	2 minutes (2, 3) *n* = 547
Fetal position during shoulder dystocia documented, *n* (%)	20 (6.2)***	58 (22.1)	423 (75.3)***
Delivery of shoulders completed by:			
Student midwife or student doctor, *n* (%)	14 (4.3)	7 (2.7)	24 (4.3)
Midwife, *n* (%)	221 (68.2)	169 (64.5)	247 (44.0)***
Obstetric trainee, *n* (%)	78 (24.1)	79 (30.2)	244 (43.3)***
Consultant/Attending obstetrician, *n* (%)	0 (0.0)***	4 (1.5)	34 (6.0)***
Unknown, *n* (%)	11 (3.4)	3 (1.2)	15 (2.66)

Group comparisons were conducted with a modified Poisson regression except for the Head-to-body delivery times, which were compared using Kruskal–Wallis test.
Significantly different from early training period *$P < 0.05$; ***$P < 0.001$.

Table 3. Neonatal morbidity associated with shoulder dystocia

	Pre-training (1996–99)	Early training (2001–04)	Late training (2009–12)
Neonatal morbidity per case of shoulder dystocia (%)			
n	324	262	562
Brachial plexus injury at birth	24 (7.4)*	6 (2.3)	7 (1.3)
Brachial plexus injury at 6 months	9 (2.8)	2 (0.8)	1 (0.2)
Brachial plexus injury at 12 months	6 (1.9)	2 (0.8)	0 (0.0)
Fractured clavicle or humerus	6 (1.9)	2 (0.8)	1 (0.2)
Apgar <7 at 5 minutes	12 (3.7)	6 (2.3)	8 (1.4)
Shoulder dystocia related neonatal morbidity per 1000 vaginal births			
n	15 908	13 117	17 037
Brachial plexus injury at birth	1.51*	0.46	0.41
Brachial plexus injury at 6 months	0.57	0.15	0.06
Brachial plexus injury at 12 months	0.38	0.15	0.00
Fractured clavicle or humerus	0.38	0.15	0.06
Apgar <7 at 5 minutes	0.75	0.46	0.47

Group comparisons conducted with a modified Poisson regression.
*Statistically significantly different from early training period $P < 0.01$.

higher risk cases were selectively delivered abdominally. The characteristics of vaginal births were comparable over the each of the time periods studied; however, with very similar average birthweights and proportions of large babies before and after training (Table 1), suggesting strongly that this was not the case. The increased shoulder dystocia rate in the 2009–12 cohort may not be solely the result of the changing characteristics of women giving birth, but could

partly be the result of increased recognition of the condition. If such a phenomenon included a greater proportion of milder cases, then the rate of complications for that condition will be reduced. We overcame any effect of an increased proportion of milder cases by looking at the rate of complication within complete cohorts, and not simply those who had shoulder dystocia. This analysis shows that the decrease in the rate of morbidity is maintained even when morbidity is expressed as a function of all vaginal births, and not just those complicated by shoulder dystocia (Table 3). Moreover, the introduction of a shoulder dystocia pro forma in July 2003 may well account for some the improvements in documentation observed with time.[26] However, although comprehensive documentation may reflect competent management, in itself documentation cannot alter clinical outcomes. One other criticism could be that this study was not a randomised-controlled trial and therefore the association between shoulder dystocia training and improved clinical outcomes might be the result of other (unrecognised) factors. However, the association between on-going annual training, the continual improvement of management and documentation of shoulder dystocia, and low neonatal morbidity is both strong and biologically plausible.

We would argue that the evidence linking this annual practical, multi-professional shoulder dystocia training to improved clinical outcomes is now sufficiently robust that it would be unethical to randomise to a control arm with no practical training. Moreover, the advantage of practice-based research used in this study is that staff who documented their clinical management and the associated clinical outcomes were not aware that they were being assessed, avoiding the Hawthorne effect. Finally, there was a prolonged review period that means that the study reflects how training in real-life can alter management and outcomes, rather than how outcomes can be altered under the spotlight of a short-term interventional trial.

One very important advantage of this study is that it provided a good test of training; there was a high level of compliance with the training requirements throughout the study period with more than 85% of professionals providing maternity care at NBT being trained annually. This research also benefited from an evidenced-based training programme run by experienced trainers within an institution committed to mandatory training. One other important advantage of this study is that we used a common approach across all time periods and believe that our triangulation for the identification of neonatal injuries (review of maternal and neonatal medical notes, risk management and paediatric physiotherapy databases) makes it highly unlikely that we have missed any cases of significant neonatal morbidity in this review. We accept that the data for this study were analysed retrospectively, but all data were prospectively collected at the time of birth and so there should be no bias across groups.

Interpretation (in light of other evidence)

Our data provide further strong evidence that practical training to implement evidence-based guidelines can improve the outcomes for shoulder dystocia. Training interventions may not be sustained over time,[27] and the evidence from the third cohort demonstrates that the beneficial effects of training did not depreciate over time but instead continued to progress, with parallel improvements in evidence-based management of shoulder dystocia and neonatal outcomes. These improvements occurred on a background of higher rates of risk factors for shoulder dystocia among the third cohort of women (higher nulliparity rate, higher gestational diabetes rate, higher obesity rate). It is notable that there was no case of permanent BPI in 562 cases of shoulder dystocia with no rise in the risk of a low Apgar score: suggesting that the avoidance of injury was not at the expense of greater hypoxic–ischaemic injury. There have been no substantial changes in the management of BPI over the time period studied, which would be likely to have reduced the incidence of permanent injury, however neonatal resuscitation was taught alongside the management of shoulder dystocia, and it is therefore possible that this training may have influenced the 5-minute Apgar score.

Our study also demonstrates that it is possible to introduce and sustain an in-house programme in which most intrapartum-care workers undergo annual hands-on practical training on the management of shoulder dystocia. This requires investment for the organisation of the training and release of staff from clinical duties. However, in addition to the health and social gains, there are significant financial benefits in the long term. If all units in England could achieve the same results then the NHS Litigation Authority could save up to £10 million per year in litigation costs alone.[10] In the USA, shoulder dystocia is the second most commonly litigated complication of childbirth.[9] In addition to the important potential reduction in neonatal morbidity, clinically effective shoulder dystocia training may have other financial and workforce benefits. A 2007 survey of over 850 obstetricians, midwives and family doctors in Michigan State, USA reported that the risk of malpractice litigation was one of the most cited factors affecting providers' decision to cease working in obstetrics and midwifery.[28] A study in Denmark reported that after the introduction of multi-professional obstetric emergency training, there was an associated significant reduction in midwifery sick leave.[29] Providing staff with the necessary skills to manage shoulder dystocia may improve the management of, and reduce the threat of litigation following,

shoulder dystocia, which may in turn reduce staff stress and absenteeism.

This, together with the improvement in the performance of recognised resolution manoeuvres, suggests that staff have become more skilled at managing shoulder dystocia. The publication of evidence or guidelines does not improve clinical outcomes; outcome improvement requires implementation of evidence. Our data suggest that practical shoulder dystocia training for all staff is a very effective method of preventing harm after this potentially dangerous obstetric emergency; institutions should not delay in implementing this evidence into practice. There are also medico-legal implications from these data. That none of 17 039 babies in the last cohort suffered permanent BPI challenges a commonly held view that permanent injury is largely unavoidable. Permanent brachial plexus injuries must no longer be viewed as an inevitable complication of shoulder dystocia.

There are a number of publications investigating the incidence of BPI pre- and post-training intervention,[8,19–21] but they are difficult to compare because the incidence is expressed with different denominators. We suggest that this could usefully be standardised: the expression and publication of permanent brachial plexus injury rate as (i) the proportion of cases of shoulder dystocia, (ii) the proportion of vaginal births, and (iii) the proportion of total births.

Conclusion

Continuation of an annual programme of mandatory, multi-professional training for intrapartum emergencies that included 30 minutes of hands-on shoulder dystocia training, for all maternity staff is feasible in the long term. This paper provides further evidence that effective training of staff is key to more effective management of shoulder dystocia; improvement in neonatal outcomes is explained by better compliance with international care standards. Sustainable, long-term staff training with monitoring of effect should be a priority for all maternity healthcare organisations.

Disclosure of interests

JC and TD are members of the PROMPT Maternity Foundation (a registered Charity in England and Wales); they receive no financial benefit from this association.

Contribution to authorship

JC analysed shoulder dystocia notes and wrote the manuscript, EL conducted the statistical analysis, GB, ST and HC analysed shoulder dystocia notes, DO analysed the neonatal records, RF and TD co-wrote the manuscript with JC. All authors must accept responsibility for the paper as published.

Details of ethics approval

Ethical committee approval was obtained from the Hampshire A Research Ethics Committee on 4 November 2013 (13/SC/0570).

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Number and proportion of staff trained per year.

Table S2. Characteristics of births complicated by shoulder dystocia. ■

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