BJA

British Journal of Anaesthesia, 125 (4): 580–587 (2020)

doi: 10.1016/j.bja.2020.06.053
Advance Access Publication Date: 28 July 2020
Obstetric Anaesthesia

Obstetric anaesthetic practice in the UK: a descriptive analysis of the National Obstetric Anaesthetic Database 2009–14

James H. Bamber[1,*], Dominique N. Lucas[2], Felicity Plaat[3] and Robin Russell[4]

[1]Department of Anaesthesia, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK, [2]London North West NHS Healthcare, Harrow, UK, [3]Department of Anaesthesia, Queen Charlottes and Chelsea Hospital, London, UK and [4]Nuffield Department of Anaesthetics, Oxford University Hospitals NHS Foundation Trust, Oxford, UK

*Corresponding author. E-mail: james.bamber@addenbrookes.nhs.uk

Abstract

Background: Data on UK obstetric anaesthetic practice between 2009 and 2014 were collected by the Obstetric Anaesthetists' Association's National Obstetric Anaesthetic Database. This database provides information on workload, variation in practice, and complication rates.

Methods: During 2009–14, data were submitted by 190 UK hospitals. The number of hospitals that submitted data each year ranged between 114 and 145. During this 6 yr period, between 27 and 35 data items were requested, although not all hospitals submitted information on all data items. The dataset was assessed for quality and only those data items with acceptable quality were analysed.

Results: The dataset contains information on 3 030 493 deliveries, 770 545 Caesarean sections, 623 050 women with labour neuraxial analgesia, and 61 121 general anaesthetics for Caesarean section. There was increased use of patient-controlled regimens for labour neuraxial analgesia over the 6 yr period. The mean rate of general anaesthesia used for Caesarean section was 8.75% (95% confidence interval, 8.26–9.24%). The rate of failed intubation for general anaesthesia for Caesarean section was one in 379. Inadvertent dural puncture rates varied between hospitals with a mean of 1.2% (95% confidence interval, 1.02–1.37%). The rate of a high neuraxial block causing unconsciousness was one in 6667 for all blocks.

Conclusions: This unique large dataset provides a valuable insight of obstetric anaesthetic activity in the UK. Although missing data may place limitations on interpretation, it provides comparative estimates for the rates of rare complications and highlights variations in practice in time and place.

Keywords: anaesthesia complications; Caesarean section; epidural analgesia; healthcare benchmarking; obstetric anaesthesia; quality improvement; workload

Editor's key points

- The Obstetric Anaesthetists' Association's National Obstetric Anaesthetic Database is a valuable resource, providing information on peripartum anaesthesia and analgesia from the entire National Health Service.
- Over the period covered, approximately 25% of women had Caesarian sections, of which 8.75% were with general anaesthesia, with a failed intubation rate of one in 379.
- Almost 21% of women had neuraxial labour analgesia, with patient-controlled epidural analgesia becoming more popular over time.
- There were very few serious complications of neuraxial analgesia, including loss of consciousness, permanent neurological injury, and cardiac arrest.

Received: 23 March 2020; **Accepted:** 3 June 2020

In the UK there are more than 700 000 deliveries annually in NHS hospitals, of which anaesthetists are involved in more than 60% of cases.[1] Despite this, there is a paucity of data about anaesthesia interventions for labour and Caesarean section (CS) and subsequent outcomes. Where data are available, concerns exist about their validity; the 5th UK National Audit Project reported figures for two incidences of accidental awareness during obstetric general anaesthesia (GA) because of concerns about accuracy of the denominator data.[2]

In 1999, the Obstetric Anaesthetists' Association (OAA) initiated a national UK survey primarily to gather information on postpartum headaches. Over the following years, the survey evolved to become the National Obstetric Anaesthetic Database (NOAD) that included a variety of questions about obstetric anaesthetic workload and practice. The dataset expanded from 16 items in 2004 to 35 items in 2014. Between 2009 and 2014, the dataset was consistent allowing detailed comparative analysis. Data collection for 2015 was suspended in 2016 to allow appraisal of the utility of the NOAD process and a re-evaluation of how data collection could best assist with quality improvement in obstetric anaesthesia.

We present an analysis of this valuable and unique UK national dataset of obstetric anaesthesia activity between 2009 and 2014 on the provision of obstetric analgesia and anaesthesia and complication rates so to better understand practice and outcomes.

Methods

National Obstetric Anaesthetic Database data collection

Data were sought from all UK lead obstetric anaesthetists known to the OAA Secretariat. Between 2009 and 2014, an online process was established for data collection. If no data were received, reminder e-mails were sent. No patient identifiable data were collected.

The dataset was divided into four categories:

1 General demographic and obstetric data
2 Mode of labour analgesia
3 Mode of anaesthesia for CS
4 Complications and ICU admissions

Data quality

External health data analysts undertook an independent quality review and analysis of the dataset. The quality of each data item was flagged as 'good' (some quality issues, but generally data were complete and consistent), 'some concerns' (some gaps, inconsistencies in data, or both), or 'poor' (significant gaps, inconsistencies in data, or both) (Supplementary Table S1). Fields for which data were rated either 'good' or 'some concerns' were submitted to further analysis.

Missing data

A mean substitution single imputation strategy with means averaged for the 6 yr of the survey was used for data field analysis except rare events. This strategy was compared with a multiple imputation strategy (Bayesian model, Markov chain Monte Carlo algorithm; Blimp version 2.2.2). The means and 95% confidence intervals (CIs) were near identical between the two methods. Accepting its limitations, our chosen strategy was preferred because of multiple imputation generating implausible data values in a small number of cases producing anomalous hospital comparisons. Analysis of maternity data in hospitals with either high or low frequency of participation showed that maternity activity during the 6 yr of the survey was consistent which supported an averaging strategy.

For rare events, all those reported over the 6 yr period were totalled and divided by the relevant totalled denominator to calculate the rates.

Data analysis

Microsoft Excel for Mac (Microsoft Corp., Redmond, WA, USA) and StatPlus for Mac (AnalystSoft Inc., Walnut, CA, USA) were used for data analysis. CIs were calculated using the Public Health England tool.[3] CIs for rare events were derived with binomial probability tests using the 'statconf programme' in *Handbook of Biological Statistics* (2014)[4] as previously used in the Royal College of Anaesthetists' National Audit Projects.[5,6] Funnel plots were generated using a Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) macro calculator created by Public Health England.[7] CIs are 95%.

Table 1 Participation by year of National Obstetric Anaesthetic Database (NOAD) survey and by hospital size and location.

	2009	2010	2011	2012	2013	2014
No. of hospitals (2009–14, *n*=190), *n* (%)	131 (69)	113 (59)	144 (76)	140 (74)	138 (73)	122 (64)
Hospital size (2009–14)	2009–14 within same size category (%)					
Small (*n*=29)	66	59	79	79	69	55
Medium (*n*=76)	72	62	72	70	70	59
Large (*n*=66)	64	58	80	79	80	71
Very large (*n*=18)	83	61	72	67	67	78
NHS region	2009–14 within same region (%)					
London (*n*=24)	63	46	71	63	67	46
Midlands and East (*n*=42)	79	67	76	83	81	67
North (*n*=49)	76	56	70	70	66	62
South (*n*=36)	73	62	78	70	62	68
Scotland (*n*=17)	53	65	100	88	88	71
Wales (*n*=13)	85	69	77	92	100	85
Northern Ireland (*n*=7)	71	71	86	57	71	57

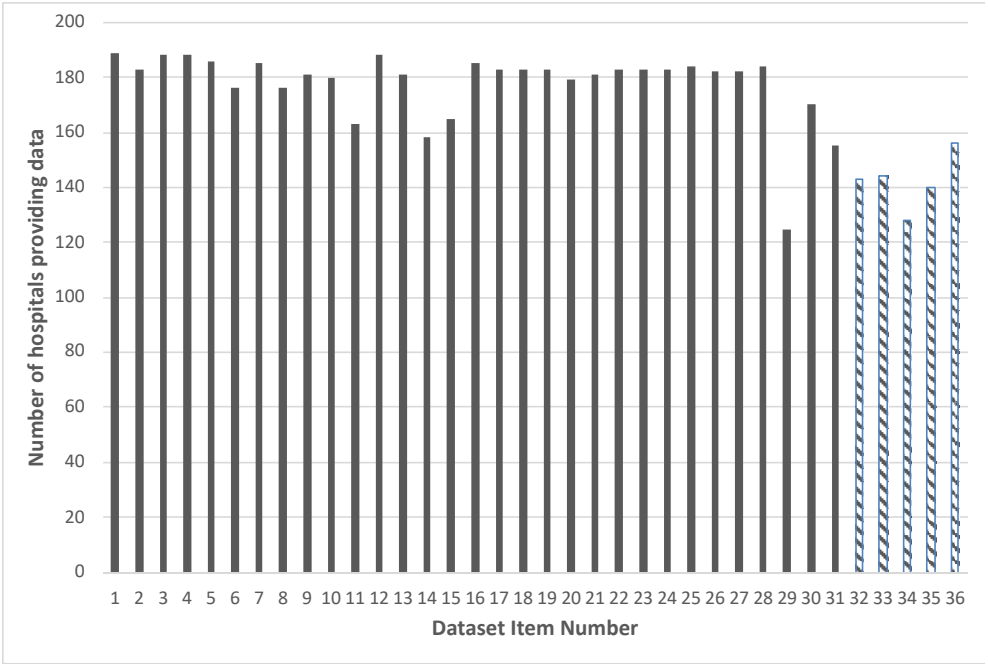

Fig. 1. Number of hospitals providing data for each dataset item for at least 1 yr between 2009 and 2014. Striped columns represent dataset items with 'Poor' quality rating (see Supplementary Table S1 for dataset item description).

For sub-analysis, participating hospitals were divided by number of deliveries each year: small (<2000), medium (2000–3999), large (4000–5999), and very large (≥6000). Hospitals were also categorised by country and region.

There is no publicly accessible single maternity dataset for the entire UK. However, the National Maternity and Perinatal Audit (NMPA) has published maternity data for England, Scotland, and Wales for a year in 2016–17 and some maternity statistics from UK regions for 2009–20 are publicly available which can be used as a comparator for the NOAD dataset.[1,8–17]

Results

Number of hospitals participating and their frequency

Over the 6 yr of the NOAD survey, 190 UK consultant-led maternity units with obstetric anaesthetic services submitted data. Of these, 79% were in England, 9% in Scotland, 7% in Wales, 4% in Northern Ireland with the remaining 1% representing hospitals from the Isle of Man and Channel Islands. From 2009 to 2014, 58 hospitals submitted data every year, whereas 21 hospitals submitted data for only 1 of the 6 yr (Supplementary Table S2). The remaining hospitals submitted data for a variable number of years.

A higher proportion of hospitals in Wales and Scotland participated compared with England. Within NHS regions in England the highest participation was in the Midlands and East with hospitals in London providing the lowest average participation (Table 1). There were no participation differences when hospitals were compared by size (number of deliveries). Not all participating hospitals submitted data for all dataset items (Fig 1). The submission rate for each data item was used as a quality indicator for that item.

Comparing NOAD and NHS maternity data

Between 2009 and 2014, data were submitted on 3 030 493 deliveries. Of these, 770 545 were by CS, of which 61 121 were under GA. There were 623 050 women reported to have received neuraxial analgesia for labour. Estimates derived from national maternity data suggest that the annual NOAD dataset returns captured approximately 70% of all deliveries and CS in the UK each year.

Comparing workload activity with time

The annual variation of activity for those hospitals that returned data every year for each of these dataset items was analysed by a one-way analysis of variance. For number of deliveries ($F_{5,342}$=0.13; P=0.99), number of CS ($F_{5,330}$=0.28; P=0.92), number of women who received labour neuraxial analgesia ($F_{5,312}$=0.21; P=0.96), number of GA ($F_{5,318}$=0.82; P=0.53), and inadvertent dural punctures ($F_{5,228}$=1.41; P=0.22), there were no significant differences in annual numbers, which implied consistent hospital maternity activity between 2009 and 2014. The same analysis was also undertaken for those hospitals that only submitted data for 2 or 3 yr with no significant differences found.

The average annual number of deliveries (721 316) and CS (182 601) calculated from all the 2009–14 NOAD dataset is estimated to correspond to 95% of annual averaged UK totals derived from national reports over the same period (Table 2). The average annual number of women who had labour neuraxial analgesia in the UK using NOAD data was 150 993, representing 21% of all deliveries reported by participating hospitals.

Table 2 Totals of hospital annual averages of reported data to National Obstetric Anaesthetic Database (NOAD) (2009–14) by all respondent hospitals. N, number of hospitals that provided data for any year.

Dataset item	Total annual average (2009–14)
Deliveries	721 316 (*N*=189)
Caesarean sections (CS)	182 601 (*N*=188)
under general anaesthesia	14 952 (*N*=186)
with single-short spinal	112 282 (*N*=185)
under *de novo* combined spinal epidural	14 482 (*N*=180)
under topped-up labour epidural	34 547 (*N*=181)
under *de novo* epidural	1660 (*N*=176)
Women with labour epidural analgesia	150 993 (*N*=188)

Mode of labour analgesia

All 190 participating hospitals submitted data for at least 1 yr on the number of women who received labour neuraxial analgesia. Of these, 96% submitted data on details of the method of maintaining neuraxial analgesia. Maintenance regimens categorised by the NOAD survey were continuous infusion, midwife intermittent boluses (MIB), patient-controlled epidural with background infusion (PCEA+BI), and patient-controlled epidural without background infusion (PCEA–BI).

Although some hospitals provided a mixture of neuraxial labour analgesia maintenance regimens, 93% of respondent hospitals used one particular regimen for ≥90% of women. For those hospitals that used one particular epidural maintenance regimen (i.e. in ≥90% of women in that hospital who had neuraxial labour analgesia), analysis shows that between 2009 and 2014 there was a move away from continuous infusion and MIB towards using PCEA with or without background continuous infusions (Fig 2). A sub-analysis of 50 hospitals that submitted maintenance regime data for all 6 yr confirmed this trend, the percentage of hospitals using either continuous infusion or MIB decreasing from 72% (2009) to 46% (2014) and those using PCEA regimes increasing from 24% to 46%.

Between 2011 and 2014, the NOAD survey had requested data on the use of intravenous patient-controlled analgesia (IV-PCA) but not specifically on remifentanil use. Data on IV-PCA use was provided by 158 hospitals. For these hospitals, the average percentage of deliveries that used IV-PCA was 0.6% (95% CI, 0.2–1.0%).

Only six of 158 respondent hospitals provided IV-PCA to >5% of deliveries; this limit arbitrarily was chosen to identify those hospitals that may have used IV-PCA regularly for labour analgesia rather than occasionally (e.g. when neuraxial analgesia is contraindicated). For these six hospitals, IV-PCA was used for a mean 11.2% deliveries (range, 5.9–28.4%). The NOAD dataset does not provide data on the number of the women who laboured; the actual percentage of women who received IV-PCA for labour analgesia would be higher if non-labouring women were excluded from the deliveries' denominator.

Between 2011 and 2014, the NOAD dataset collected data (given by 41 hospitals) on the number of women who received labour analgesia via a spinal catheter. In these hospitals, a spinal catheter used for labour analgesia represented 0.08% of deliveries (95% CI, 0.05–0.12) and 0.39% (95% CI, 0.23–0.55) of women who received neuraxial analgesia in labour.

Mode of anaesthesia for Caesarean section

For those 185 hospitals that provided data, 'single-shot' spinal (SSS) anaesthesia was the predominant technique. In 156 hospitals it was used for >50% of women who had a CS. In

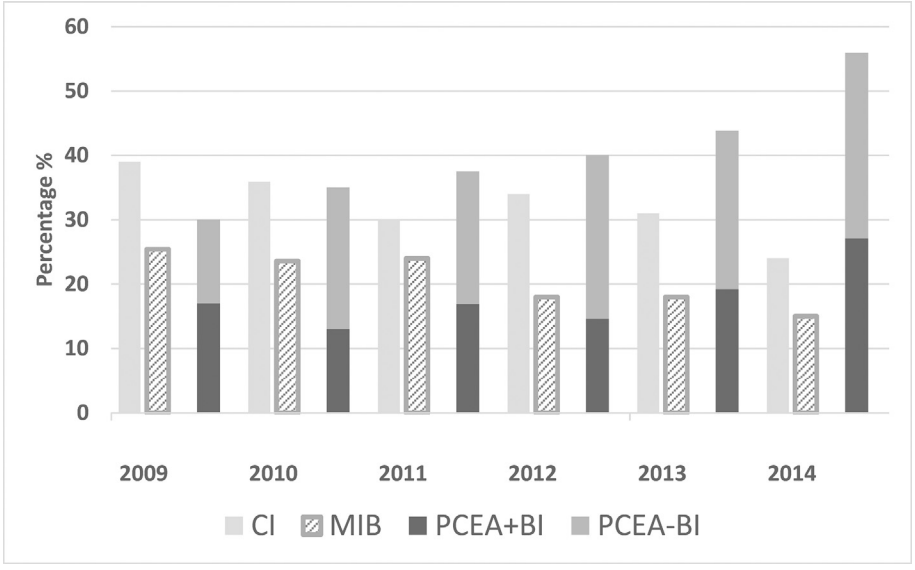

Fig. 2. Percentage of hospitals that used a particular epidural analgesia maintenance regime for >90% of their women who had LEA in each survey year. CI, continuous infusion; LEA, labour epidural analgesia; MIB, midwife intermittent bolusing; PCEA+BI, patient-controlled epidural analgesia with background infusion; PCEA–BI, patient-controlled epidural analgesia without background infusion.

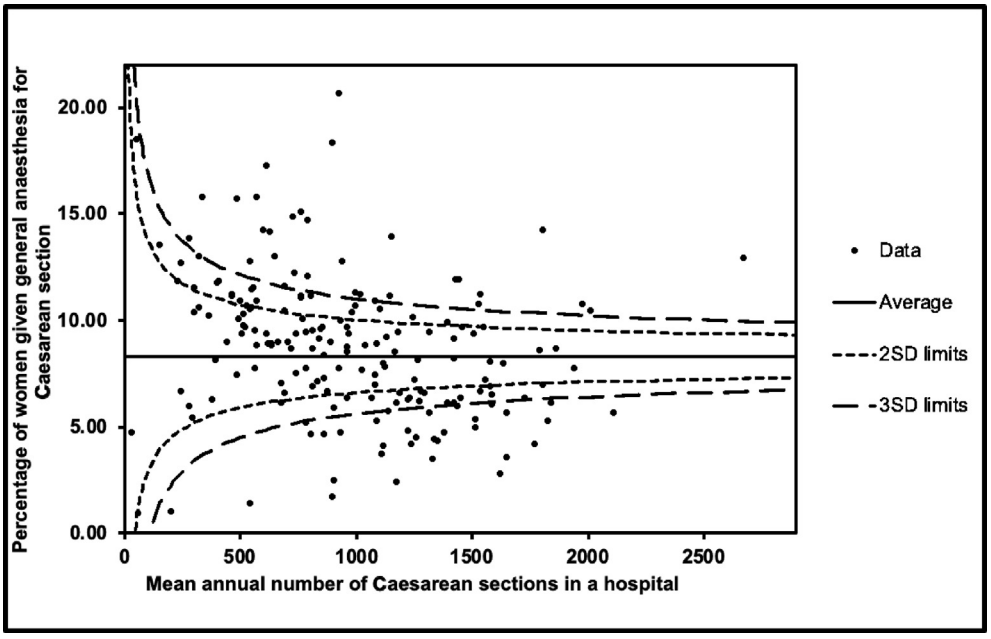

Fig. 3. Annual average percentage of women for each respondent hospital who have general anaesthesia for Caesarean section. SD, standard deviation.

comparison, there were only five hospitals in which *de novo* combined spinal–epidural (CSE) anaesthesia was used for >50% women who had CS. There was no difference in the rates of GA for CS between hospitals in which SSS anaesthesia was predominant compared with those hospitals for which CSE anaesthesia predominated (9.1% [95% CI, 8.6–9.6%] *vs* 9.4% [95% CI, 3.1–15.7%], test statistic=0.12, *df*=4, *P*=0.91), but the CIs are wide for the CSE group because of the small number of hospitals represented.

Data on the use of GA was provided by 184 hospitals. The mean overall rate of CS under GA over the 6 yr was 8.75% (95% CI, 8.26–9.24%), but there was notable variation between hospitals (Fig 3).

Complications and ICU admissions

Data were provided by 170 hospitals on 2684 women admitted for level 3 intensive care (Intensive Care Society definition 'advanced respiratory support alone, or basic respiratory support together with support of at least two organ systems'[18]). The mean rate of admission to ICU per 1000 deliveries was 1.08 (95% CI, 0.96–1.20). There were regional variations in the number of reported admissions. The highest rate of admissions per 1000 deliveries was in London (1.62; 95% CI, 1.10–2.13), whereas the lowest was the North of England (0.78; 95% CI, 0.62–0.93).

Data on the rate of inadvertent dural punctures were provided by 177 hospitals. The mean annual rate of inadvertent dural puncture with an epidural needle was 1.2% (95% CI, 1.02–1.37); the hospital variation is shown in the funnel plot in Supplemental Figure S1.

Data on rare complications are shown in Table 3. The rate of failed intubation for GA was one in 379 (95% CI, 1/324–1/446) whereas the reported rate of 'cannot intubate, cannot ventilate' (CICV) for GA was one in 4072 (95% CI, 1/239–1/7143).

The rate of a high block resulting in unconsciousness was one in 6667 (95% CI, 1/5583–1/7692) in women who received neuraxial anaesthesia or analgesia. The rate of cardiac arrest or convulsions as a result of local anaesthetic toxicity was one in 56 330 women if the denominator was those women who received labour epidural analgesia and one in 61 853 women if the denominator was women who received epidural analgesia, anaesthesia, or both.

The rate of permanent nerve injury after neuraxial analgesia, anaesthesia, or both was one in 20 000 (95% CI, 1/14 286–1/33 333). Data provided for rare complications associated with neuraxial techniques did not provide information on the technique used.

Discussion

Quality of data and participation

The NOAD dataset is a unique source of information on UK obstetric anaesthetic practice which will be useful for anaesthetists both in the UK and those practising in other countries. Owing to maternity care reconfiguration between 2009 and 2014, it is uncertain what percentage of UK consultant-led maternity units returned data for at least 1 yr of the survey. Using a variety of sources,[1,19,20] we have estimated that the 190 participating hospitals represented at least 90% of UK units that provided labour neuraxial analgesia.

Missing data have been compensated for in parts by our chosen imputation strategy but may have implications for how incidences, particularly for rare events, are interpreted.

Our analysis indicates that each hospital's maternity activity did not change significantly from year to year over the

Table 3 Rare complications reported to NOAD as a rate of number of women for a particular type of anaesthesia or analgesia. CS, Caesarean sections; NOAD, National Obstetric Anaesthetic Database.

Complication	NOAD data 2009–14
Complication rate per 100 000 women who had regional anaesthesia or analgesia	
High block resulting in loss of consciousness	15 (95% CI, 13–17)
Local anaesthetic toxicity: Number of women who cardiac arrest or convulsions with regional anaesthesia/ analgesia	2 (95% CI, 0–3.0)
Number of women who had permanent nerve damage after regional anaesthesia or analgesia	5 (95% CI, 3–7)
Complication rate per 100 000 women who had general anaesthesia for CS	
Failed intubation	264 (95% CI, 224–308)
'Cannot intubate, cannot ventilate'	25 (95% CI, 14–41)

duration of the survey period. Calculated annual estimates of activity are in concordance with annual published maternity statistics and data from other sources.[1,8–17] The annual number of obstetric neuraxial blocks calculated from the NOAD dataset (279 416) was compared with the number estimated by extrapolation in the Third National Audit Project (NAP3)[5] (320 425). The difference between numbers in NOAD and NAP3 may reflect different calculation methods but also NOAD only collected data on CS neuraxial blocks.

The NOAD dataset has demonstrated variation in practice. Whether this variation is a result of differences in data reporting or whether it represents a true variation in practice requires investigation.

Labour analgesia

The NOAD survey demonstrated the increasing popularity of PCEA. Its use doubled over the 6 yr of the survey, and by 2014 it was the technique used by the majority of women in 50% of respondent hospitals. The recent introduction of technology that allows programmed mandatory bolusing may facilitate a further change in practice.

Data collected on IV-PCA were not specifically about the use of remifentanil. Although morphine and fentanyl IV-PCA might have been used in some labours, particularly in those involving termination of pregnancy or management of intrauterine death, it is likely that the majority of women received the short-acting opioid remifentanil. Only 4% of units reported that intravenous labour analgesia was used in >5% of deliveries. The recent publication of results from the RESPITE (remifentanil patient-controlled analgesia *vs* intramuscular pethidine for pain relief in labour) study[21] may encourage the uptake of remifentanil IV-PCA as an option for labour analgesia.

Anaesthesia for Caeserean section

Spinal anaesthesia continues to be the most popular technique for CS, although in some units CSE is preferred. This may reflect a different case mix in which more complicated and time consuming surgery is more commonly performed. Alternatively, it may simply be a matter of personal preference. Rates of GA ranged from <2% to >20% with a mean of 8.75%. This variation may again result from the case mix and the influence of senior anaesthetic staff.

Complications and ICU admissions

There was a mean rate of 1.08 per 1000 deliveries that required level 3 ICU admission. This is less than that reported by the NMPA, 2.24 admissions per 1000 women in pregnancy, during childbirth and up to 6 weeks postpartum.[22] The NMPA used data linkage between the Intensive Care National Audit and Research Centre Case Mix Programme, Scottish Intensive Care Society Audit Group audit dataset, and national maternity information datasets which may achieve greater precision and capture of data compared with NOAD data. Another important factor is case definition. NOAD requested data on those women who required level 3 care, whereas the NMPA data included all admissions to ICU which may have included women requiring level 2 care ('detailed observation or intervention including support for a single failing organ system or post operative care'[18]). Finally, the denominator used for the NOAD rate was the number of deliveries rather than the number of women, and NOAD data may have missed antenatal and late postpartum admissions.

The rate of failed intubation for GA (one in 379) is less than that reported in a UK Obstetric Surveillance System (UKOSS) study between 2008 and 2010, which calculated the rate to be one in 224.[23] NOAD had reports of 161 failed intubations over 6 yr, an average of 27 cases per year, close to that reported to UKOSS with 28.5 cases per year. The strength of the UKOSS study is its methodology of case ascertainment. Its weakness, however, was estimating the total number of all UK obstetric GA by a mathematical formula to extrapolate index cases to calculate a number of 6400 per year. Maternity Data 2009–10 for England reported that the number of GA given for CS was 7531 (4.8% of CS).[8] If the NOAD annual number of GA in UK for CS (14 952) was used in UKOSS calculations, the two rates would be similar.

The rate for failed intubation is more common than that in a large dataset of American practice (one in 533 for 5332 obstetric GA) and the rate of one in 443 calculated in a literature review of 27 publications reporting on 88 000 obstetric GA.[24,25] This review included studies with divergent rates of failed intubation (one/270 and zero/2802) for similar numbers of obstetric GA (≈2000).[26,27] The reasons for these differences are unclear but may include experience of the anaesthetist and the number of GA given, but also case definition and ascertainment. Obstetric GA is performed infrequently. Strategies including structured training and the use of videolaryngoscopy may be crucial for safety. A national survey in 2011 reported that only 42% of obstetric units had a

videolaryngoscope available.[28] Future studies may identify whether the introduction and widespread use of videolaryngoscopy has had an impact on the failed intubation rate in obstetrics.

NAP3[5] provided limited data on the risks of neurological complications associated with neuraxial techniques in obstetrics; there were two confirmed reports of major nerve injury associated with neuraxial anaesthesia with a denominator estimated to be 320 425, giving a rate of 0.3 cases per 100 000 blocks. In contrast, there were 28 cases of permanent nerve injury reported to NOAD for the 3 yr that these data were collected, a rate of five per 100 000. The NOAD survey did not distinguish the severity of injury and only asked whether the injury was 'permanent'. It is possible the 10-fold discrepancy between these two figures is attributable to inaccurate reporting of cases to NOAD or that more minor cases of permanent injury were included in NOAD reports. Nevertheless this information may further aid the discussion and process of seeking consent before a neuraxial procedure.

Cardiac arrest in obstetrics was assessed in a 3 yr UKOSS study in which there were 13 cardiac arrests associated with neuraxial anaesthesia.[29] This gives a rate of 1.54 per 100 000 neuraxial blocks if the NOAD annual average number neuraxial blocks (279 417) is used as the denominator. The incidence of cardiac arrest, convulsions, or both attributed to local anaesthetic toxicity calculated from NOAD data is two per 100 000 neuraxial blocks.

For rare events, our data can only provide an estimate of cases because of risks of reporter bias and missed cases.

Limitations

This was a large-scale data collection over 6 yr, collating data returns from lead obstetric anaesthetists in UK maternity hospitals. Inevitably, the data collection is incomplete. Data items with significant proportion of missing data have been excluded from the analysis. Where possible the findings have been compared with those from other sources with favourable results. However, the limitations as a result of missing data need to be taken into account when appraising the results of this analysis.

Conclusions

This work provides the most comprehensive analysis of UK data for obstetric anaesthesia to date. It also demonstrates that further studies and data collection need to focus on examining variation of practice. Lessons derived from the experience of NOAD include the importance of clear case definition and the challenges faced by local reporters to access data about their obstetric anaesthetic services which has been highlighted elsewhere.[30] The OAA is now examining options for future data collection for key quality indicators to help drive a national quality improvement agenda in obstetric anaesthesia and for benchmarking.[31]

Authors' contributions

Data analysis/interpretation; drafting and critical revision of the manuscript; approving the final version of the manuscript: all authors

Accountable for all aspects of the work: all authors

Acknowledgements

Independent data analysis was commissioned by the OAA from Solutions for Public Health (Oxfordshire, UK) and Analytics Cambridge Ltd (Cambridgeshire, UK) who assessed the quality of the data, formatted the data for analysis, and undertook preliminary interrogation of the data. The authors acknowledge the contribution of colleagues who were members of the OAA NOAD subcommittee and particularly the chairs of the subcommittee who supervised the data collection between 2009 and 2014: Philip Barclay, Makani Purva, and Marc Van de Velde. Data collection would not have been possible without the assistance of Trisha Hawkins and the OAA Secretariat. Finally, on behalf of the OAA, the authors thank the commitment and work of all the lead obstetric anaesthetists who contributed data to NOAD over many years.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.06.053.

Declarations of interest

All authors are members of the Executive Committee of the Obstetric Anaesthetists' Association.

Funding

The Obstetric Anaesthetists Association to Solutions for Public Health (Oxfordshire, UK), and Analytics Cambridge Ltd (Cambridgeshire, UK) for dataset preparation and analytical work on behalf of the Obstetric Anaesthetists Association.

References

1. NMPA Project Team. *National maternity and perinatal audit: clinical report 2019. Based on births in NHS maternity services between 1 april 2016 and 31 march 2017*. London: RCOG; 2019
2. The Royal College of Anaesthetists and the Association of Anaesthetists of Great Britain and Ireland. In: *The 5th national audit Project. Accidental awareness during general anaesthesia in the United Kingdom*. London: RCOA and AAGBI; 2015
3. Public Health England Data Science Team. *PHE tool for common PH stats and Cis*. Available from: https://fingertips.phe.org.uk. [Accessed 23 January 2020]
4. McDonald JH. In: *Handbook of biological statistics*. 3rd edn. Baltimore, MD: Sparky House Publishing; 2014
5. Cook TM, Counsell D, Wildsmith JAW. Major complications of central neuraxial block: report on the Third national audit of the royal College of anaesthetists. *Br J Anaesth* 2009; **102**: 179–90
6. Cook TM, Woodall N, Frerk C. Major complications of airway management in the UK: results of the fourth national audit project of the royal College of anaesthetists and the difficult airway society. Part 1. *Br J Anaesth* 2011; **106**: 617–31
7. Public Health England Data Science Team. *Funnel plot tool for proportions and percentages. Funnel plot tool for proportions and percentages*. Available from: https://fingertips.phe.org.uk/documents/PHE%20Funnel%20plot%20tool%20for%20proportions.xls. [Accessed 23 January 2020]

8. NHS Digital. *NHS maternity statistics England, 2009–2010* 2010. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2009-10. [Accessed 23 January 2020]
9. NHS Digital. *NHS maternity statistics England, 2010–2011* 2011. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2010-11. [Accessed 23 January 2020]
10. NHS Digital. *NHS maternity statistics, England 2011/12* 2012. Available from: https://data.gov.uk/dataset/3408fa77-c3aa-42dd-8ff1-cd3354b62299/nhs-maternity-statistics-england-2011-12. [Accessed 23 January 2020]
11. NHS Digital. *NHS maternity statistics England, 2012–13* 2013. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2012-13. [Accessed 23 January 2020]
12. NHS Digital. *NHS maternity statistics England, 2013–14* 2015. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2013-14. [Accessed 23 January 2020]
13. NHS Digital. *NHS maternity statistics England, 2014–15* 2015. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2014-15. [Accessed 23 January 2020]
14. Information Services Division. *Births in Scottish hospitals: maternity and births* 2018. Available from: https://www.isdscotland.org/Health-Topics/Maternity-and-Births/Births/. [Accessed 23 January 2020]
15. Number StatsWales. *Of deliveries in Wales by delivery method and year*. Available from: https://statswales.gov.wales/v/FNA1. [Accessed 23 January 2020]
16. Northern Ireland Statistics and Research Agency. *Birth statistics*. Available from: https://www.nisra.gov.uk/publications/birth-statistics. [Accessed 23 January 2020]
17. Black L. *Incidence of caesarean sections. Research and information service briefing note* 2011. Available from: http://www.niassembly.gov.uk/globalassets/Documents/RaISe/Publications/2011/Health/14711.pdf. [Accessed 15 July 2020]
18. Eddleston J, Goldhill D, Morris J. *Levels of critical care for adult patients*. London: Intensive Care Society; 2009
19. *Which? (2018). Birth choice* 2018. Available from: https://www.which.co.uk/birth-choice. [Accessed 23 January 2020]
20. McCourt C, Redshaw M. Mapping maternity care facilities in England. *Evid Based Midwifery* 2011; **9**: e46
21. Wilson MJ, MacArthur C, Hewitt CA, et al. Intravenous remifentanil patient-controlled analgesia versus intramuscular pethidine for pain relief in labour (RESPITE): an open-label, multicentre, randomised controlled trial. *Lancet* 2018; **392**: 662–72
22. Jardine J, NMPA Project Team. *Maternity admissions to intensive care in England, Wales and Scotland in 2015/16: a report from the national maternity and perinatal audit*. London: RCOG; 2019
23. Quinn AC, Milne D, Columb M, Gorton H, Knight M. Failed tracheal intubation in obstetric anaesthesia: 2 yr national case–control study in the UK. *Br J Anaesth* 2013; **110**: 74–80
24. D'Angelo R, Smiley RM, Riley ET, Segal S. Serious complications related to obstetric anesthesia: the serious complication repository project of the Society for Obstetric Anesthesia and Perinatology. *Anesthesiology* 2014; **120**: 1505–12
25. Kinsella SM, Winton AL, Mushambi MC, et al. Failed tracheal intubation during obstetric general anaesthesia: a literature review. *Int J Obstet Anesth* 2015; **24**: 356–74
26. Tao W, Edwards JT, Tu F, Xie Y, Sharma SK. Incidence of unanticipated difficult airway in obstetric patients in a teaching institution. *J Anesth* 2012; **26**: 339–45
27. Pollard R, Wagner M, Grichnik K, Clyne BC, Habib AS. Prevalence of difficult intubation and failed intubation in a diverse obstetric community-based population. *Curr Med Res Opin* 2017; **33**: 2167–71
28. Lucas DN, Vaughan DJA. Videolaryngoscopy and obstetric anaesthesia. *Br J Anaesth* 2017; **119**: 249
29. Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. *BJOG* 2017; **124**: 1374–81
30. Pritchard N, Lo Q, Wikner M, Bamber J. Collecting data for quality improvement in obstetric anaesthesia. *Int J Obstet Anesth* 2019; **39**: 142–3
31. Bamber JH, Lucas DN, Plaat F, Allin B, Knight M, collaborators for the Obstetric Anaesthetists' Association Quality and Outcomes Working Group. The identification of key indicators to drive quality improvement in obstetric anaesthesia: results of the Obstetric Anaesthetists' Association/National Perinatal Epidemiology Unit collaborative Delphi project. *Anaesthesia* 2020; **75**: 617–25

Handling editor: Michael Avidan