Authors' copy of paper published in *Anaesthesia*

General anaesthetic and airway management practice for obstetric surgery in England: a prospective, multi-centre observational study

P M. Odor,[1,2] S. Bampoe,[2] S. R. Moonesinghe,[1,2] J. Andrade,[3] J. J. Pandit,[4] D. N. Lucas,[5], Pan-London Perioperative Audit and Research Network (PLAN), for the DREAMY Investigators Group

[1] *Centre for Anaesthesia and Perioperative Medicine, University College London Hospital, London, UK*

[2] *Centre for Perioperative Medicine, Research Department for Targeted Intervention, University College London, UK*

[3] *School of Psychology, University of Plymouth, Plymouth, UK*

[4] *Nuffield Department of Anaesthetics, Oxford University Hospitals NHS Trust, Oxford, UK*

[5] *Department of Anaesthesia, Northwick Park Hospital, London, UK*

Correspondence to: Dr Peter Odor, Centre for Anaesthesia and Perioperative Medicine, University College London Hospital, London, UK. peter.odor@nhs.net

**Presented in part at the Obstetric Anaesthetists' Association Annual Scientific Meeting, May 2019, Newcastle*

Twitter: @peteodor, @Drsambam, @rmoonesinghe, @noolslucas, @dreamyresearch

Short title: Obstetric general anaesthesia practice in the UK

Key words: obstetrics, general anaesthesia, caesarean section, airway management

Summary

There are no current descriptions of general anaesthesia characteristics for obstetric surgery, despite recent changes to patient demographics and airway management guidelines. This analysis of data from the Direct REporting of Awareness in MaternitY patients (DREAMY) study of accidental awareness during obstetric anaesthesia aims to describe practice for obstetric general anaesthesia in England and compare with prior surveys and best practice recommendations. From May 2017 to August 2018 consenting patients receiving general anaesthesia for obstetric surgery in 72 hospitals were included. Patient demographics, airway management, anaesthetic techniques and major complications data were collected. Descriptive analysis, binary logistic regression modelling and comparisons with prior data were conducted. Data were collected from 3117 procedures, including 2554 (81.9%) caesarean deliveries. Thiopental was the induction drug in 1649 (52.9%) participants, compared to propofol in 1419 (45.5%). Suxamethonium was the neuromuscular blocking drug for tracheal intubation in 2631 (86.1%), compared with rocuronium in 367 (11.8%). Difficult intubations occurred in 1 in 18 (95% CI: 1 in 16–21); failed intubation occurred in 1 in 309 (95% CI: 1 in 170–625). Videolaryngoscopy was used rarely (1.9%). Obese patients were over-represented compared to national baselines and associated with difficult, but not failed intubation. Use of general anaesthesia induction drug (increased propofol) has changed far more than use of neuromuscular blocking drugs (suxamethonium remains most popular). Although suboptimal, there is evidence of improvement in practice with increased monitoring and reversal of neuromuscular blockade. Despite a high risk of difficult intubation in this population, videolaryngoscopy use remains rare.

Neuraxial anaesthesia is the preferred technique for most obstetric operative procedures [1]. However, general anaesthesia (GA) is still required in some clinical situations. The provision of GA in obstetric patients remains a cause for concern and debate regarding best practice, with concerns including an increased risk of failed intubation and accidental awareness during general anaesthesia (AAGA) and the impact on maternal experience [2-4].

The 5th National Audit Project (NAP5) of the Royal College of Anaesthetists and the Association of Anaesthetists of Great Britain and Ireland into accidental awareness during general anaesthesia investigated accidental awareness under general anaesthesia. Both the primary investigation and the activity survey highlighted some of the unique challenges associated with general anaesthesia in obstetrics and also some of the idiosyncrasies of practice in this area, compared to the provision of general anaesthesia outside obstetrics [1,3].

The Direct REporting of Awareness in MaternitY patients (DREAMY study) was a multi-centre, prospective cohort study that aimed to establish the incidence, risk factors and sequelae of AAGA in obstetrics [5]. A secondary study was embedded within DREAMY with the aim to describe general anaesthetic practice in obstetric patients in the UK. Specifically, this study aimed to examine choice of drugs and airway management techniques and evaluate any change in practice since NAP5[1].

Methods

This investigation was planned a priori as a descriptive cross-sectional study of general anaesthesia characteristics for patients recruited to the Direct REporting of Awareness in MaternitY patients study. Research Ethics Committee (17/LO/0071) and Health Research Authority approvals were granted, alongside prospective registration of the primary trial aims (ClinicalTrials.gov Identifier: NCT03100396). Full details of the Direct REporting of Awareness in MaternitY patients study protocol are available separately [5]. This manuscript is reported in accordance with the STROBE statement for reporting observational studies [6].

Recruitment occurred in NHS hospitals in England between May 2017 and August 2018. Data were collected on patients undergoing GA for obstetric surgery provided the following inclusion criteria were met: age ≥18 years, surgery with an obstetric indication occurring at ≥ 24/40 weeks of gestation to <48 hours postpartum and written consent. Pregnant patients receiving GA for a non-obstetric indication (e.g. colorectal surgery) were excluded, as were patients who were too unwell to participate in the AAGA interview components of the primary study and those unable to

communicate in English. The study was supported by an affiliated anaesthetic trainee network, the Pan-London Perioperative Audit and Research Network (PLAN). Collaborations with anaesthetic trainee networks outside London were invited.

Aspects of general anaesthetic conduct that were evaluated, included indications for GA, the training grade of the most senior anaesthetist present, time and duration of GA and anaesthetic induction technique (use of rapid sequence induction; RSI). Anaesthetic pharmacological data included choice and dose of induction agent, maintenance agent, neuromuscular blocking drug (NMBD) and use of neuromuscular blocking reversal agent.

Data on airway management included direct laryngoscopic view, based upon a modified version of the original Cormack and Lehane grading [7,8]. The primary airway device used, difficulties with airway management and intubation technique (including videolaryngoscopy or awake tracheal intubation) were recorded. Data were collected on critical incidents including regurgitation, aspiration and critical care admission.

Difficult intubation was defined as a clinical situation in which the most senior anaesthetist present required multiple (≥2) attempts or was unable to successfully intubate the trachea, or based on the subjective opinion of the anaesthetist as recorded on the anaesthetic chart.

Demographic data included: age of patient, parity, American Society of Anesthesiologists (ASA) physical status score, booking weight, height and body mass index. The surgical procedure was recorded, as either caesarean section (CS), exploration under anaesthesia (EUA), manual removal of placenta (MROP) or specified individually according to the procedure undertaken. Urgency of CS was classified in accordance with the model proposed by Lucas et al [9] and adopted by the Royal College of Obstetricians and Gynaecologist in the United Kingdom using Categories 1 to 4; Category 1 representing surgery needed due to immediate threat to life of the mother or baby, to Category 4 being performed electively. The urgency of non-CS procedures was classified using the NCEPOD model (immediate, urgent, expedited, elective) [10]. Results were presented separately for CS and non-CS procedures, for ease of comparison with previous and future surveys of obstetric practice.

All data was collected via an online secure database (developed using REDCap) [11]. The sample size was determined by the primary outcome in the Direct REporting of Awareness in MaternitY patients study. Descriptive statistics were calculated for patient and procedure variables. Frequency and percentage were presented for each categorical variable. For skewed continuous variables, the median and interquartile range (IQR) were calculated along with the range. Proportion of difficult

and failed intubations were calculated with 95% confidence intervals (CI). Missing data was declared for each outcome.

Continuous variables were compared using independent t-test or Wilcoxon rank-sum test, as determined by assessing normality of sample data distribution with Shapiro-Wilk testing. Categorical variables were analysed using chi-squared or Fisher's exact test. Binary logistic regression analysis was performed to identify independent factors influencing induction hypnotic drug choice and airway complications. All significant covariates after univariate testing were entered into a multivariable logistic regression analysis. Hospitals were grouped and analysed according to Health Education England anaesthetic training regions, which were expected to provide a balance between geographic distribution and relative homogeny of practice. Odds ratio (OR) with 95% confidence intervals were used to quantify effect sizes. Significance was estimated with the Wald test. All statistical analyses were performed using SPSS software (version 25, IBM, USA).

Results

Hospitals

A total 3115 patients providing written informed consent for inclusion following eligibility screening of 4969 patients. Participation included 72 (45.6%) of the 158 National Health Service hospitals where obstetric anaesthesia services are offered in England, although patient recruitment was weighted towards London and Southern England (Figure 1; Table S1). Hospitals included a mixture of teaching (22 hospitals) and district general hospitals (50 hospitals); although all hospitals were similar in providing labour ward and obstetric operating theatre facilities. The median (IQR [range]) number of patients recruited at each site was 37 (25-59 [3-146]). Four patients underwent two recorded GAs during their inpatient stay, with both anaesthetic episodes included, and two patients had no anaesthetic data reported; hence the total number of GA episodes for data analysis was 3117 (Figure 1).

Patients and operations

Baseline characteristics of included patients are provided in Table 1. Demographic data for patients who received GA for obstetric surgery were different from national baseline maternity patient statistics [12,13]. Patients receiving GA were slightly older (mean difference = 1.0 year (95% CI: 0.79 – 1.20); $p < 0.01$) and more likely to be primigravid (difference = 18.3% (95% CI: 15.7% – 19.1%); $p < 0.01$). Women with BMI ≥ 30kg.m^{-2} were marginally over-represented (difference = 3.1% (95% CI: 1.6% – 4.6%); $p < 0.01$) (Table 1).

A total of 2554 GAs (81.9%) were undertaken for CS, of which 1329 (42.6%) were classed as Category 1. Most GAs were initiated de novo, before initial surgical incision; although a minority were conversion to GA after surgery had started, typically due to inadequate neuraxial block (Table 2). The median (IQR [range]) duration of surgery was 60 (45-75 [6-390]) minutes.

Drugs and induction technique

Rapid sequence induction (RSI) was the preferred anaesthetic induction technique for the almost all patients, being used in 3099 (99.4%) participants. Thiopental was the most commonly used hypnotic drug for induction of GA, being used in 1649 (52.9%) (Table 3). Propofol was used for induction in 1419 (45.5%) of patients and ketamine in 28 (0.9%). Two patients received etomidate as their primary induction hypnotic drug. One patient received thiopental followed by additional boluses of propofol during induction of GA. One patient with severe needle phobia underwent an inhalational

induction with sevoflurane and cricoid pressure, followed by attainment of intravenous access and additional intravenous hypnotic drugs. In the majority of participants maintenance of GA was with volatile agents (Table 3 and Figure 2).

Non-CS surgery was more likely to be associated with propofol induction (OR 1.90; 95% confidence interval 1.51-2.39). All types of less urgent surgery were associated with greater propofol rather than thiopental use. The OR for propofol use for was 1.19 (95% CI: 1.10-1.29) as the urgency of surgery declined from “immediate” to “elective”. Higher categories of ASA physical status score were also associated with a higher OR of propofol use; 1.18 (95% CI: 1.03-1.35). The geographic region in which hospitals were located was also associated with variable ORs for propofol usage (Figure 3 and Table S2).

Short-acting opioids during induction of GA were given to 1351 (44.2%) of participants, of which fentanyl was the most popular choice (Table 3 and Figure 2). For CS surgery, short-acting opioid use was lower than for non-CS obstetric surgery ($p < 0.0001$).

Suxamethonium was used more frequently than rocuronium (Table 3) as the NMBD for tracheal intubation (84.5 vs. 11.4%). Of the 1620 participants that received non-depolarising NMBDs, 1427 (88.1%) received a neuromuscular blocker reversal drug. For the majority of participants, 1184 (83.0%), the drug combination used was neostigmine with glycopyrrolate. Sugammadex reversal was used in the 219 of the 533 participants (41.1%) who received rocuronium. Nerve stimulator monitoring of neuromuscular blockade was documented for 855 (52.8%) patients receiving non-depolarising NMBD.

Processed electroencephalogram (pEEG) depth of anaesthesia monitoring was applied to 148 (4.7%) patients across only seven hospital sites. No other form of depth of anaesthesia monitoring was recorded.

Airway management

Tracheal intubation was the airway management method for 3099 (99.4%) participants. The remaining 18 participants (0.6%) underwent surgery using a supraglottic airway device. A first generation device was used in three participants and second generation supraglottic airway device in 15 participants [14]. Of these 18 patients, eight (44.4%) received the supraglottic airway following failed attempts at tracheal intubation. The remaining non-rescue supraglottic airways were used predominantly in non-emergency, non-CS surgery (including insertion of cervical cerclage and

MROP). No participants required emergency front of neck access surgery for a “can’t intubate, can’t oxygenate” scenario; no cricothyrotomies were performed. There were two complications of suspected gastric aspiration during airway management.

Grade 3-4 laryngoscopy occurred in 1:38 of all GAs (95% CI: 1 in 31 – 47). A small proportion (1.4%) of airways with a grade 1 view at direct laryngoscopy were subjectively reported as difficult. These difficult intubations were associated with vocal cord oedema in the context of pre-eclampsia or technical problems (including endotracheal tube cuff leakage or difficult bag-valve mask ventilation).

Difficult intubations for all types of obstetric surgery were reported in 1 in 18 (95% CI: 1 in 16 – 21) of all GAs. For patients with reported difficult tracheal intubation, a bougie was used successfully in 103 (66.9%). Videolaryngoscopy was used rarely, in only 59 (1.9%) participants. Failed intubation occurred in 10 participants (0.32%) or 1 in 309 (95% CI 1:170 – 625). General anaesthesia was continued for nine of these participants, undergoing surgery with a supraglottic airway device. One participant received GA following unsuccessful attempts at neuraxial anaesthesia; the trachea could not be intubated, the patient was safely woken and a neuraxial block was subsequently successfully sited.

The prevalence of reported difficult intubation for CS surgery was 1 in 18 (95% CI: 1 in 15 – 21) and 1 in 20 (1 in 14 – 31) for non-CS surgery. The prevalence of failed intubation was 1 in 345 (95% CI: 1 in 169 – 909) for CS surgery and 1 in 179 (95% CI: 1 in 61 – 833) for non-CS surgery.

Two participants underwent planned awake tracheal intubation for known difficult airways using flexible bronchoscopy prior to Category 3 and 4 CS surgery. Neuraxial anaesthesia was contraindicated in both participants, who received remifentanil target-controlled infusions for sedation during airway management. Neither participants suffered any reported complications.

On regression analysis, the OR of encountering a Grade 3-4 laryngoscopy was not significantly related to weight ($p = 0.41$), BMI ($p = 0.87$), age ($p = 0.13$), grade of anaesthetist ($p = 0.74$), surgical procedure ($p = 0.58$), choice of induction hypnotic drug ($p = 0.29$), choice of NMBD ($p = 0.22$), urgency of surgery ($p = 0.51$) or whether GA was commenced prior to the initial surgical incision or during surgery, as a conversion from regional anaesthesia ($p = 0.66$). Raised BMI was not associated with Grade 3-4 laryngoscopy but was associated with difficult intubation (OR 1.09 (1.02-1.17); $p = 0.013$).

Ten participants (0.3%) had Grade 4 direct laryngoscopy views, two of which resulted in a failed intubation and subsequent rescue with a supraglottic airway devices. Videolaryngoscopy was not used for either participant. The trachea was intubated using a bougie in two participants and via videolaryngoscopy in six participants.

Staffing and workforce considerations

Over half of GAs, 1732 participants (55.6%), were started during day shift hours (08:00 to 20:00). With only 446 procedure (14.3%), the least common period of time for GAs to start was 04:00 to 08:00. Weekend days had a mean difference of 27.4% (95% CI: 26.5% – 28.3%) fewer GAs than weekdays.

Staffing for GAs differed significantly depending upon the GA start time, with consultant presence falling from 1067 (64.1%) during the day shift, to 145 (11.0%) overnight. Difficult intubations were not significantly over-reported during day shift hours, compared with overnight: 98 (5.7%) vs. 66 (4.8%; p = 0.26). Nor was Grade 3-4 laryngoscopy was over-reported during the day shift: 50 (3.9%) vs. 28 (2.0%; p = 0.15).

Discussion

The main finding of this study is about the use of anaesthetic agents; that the traditional pharmacological paradigm of thiopental and suxamethonium for RSI in obstetrics that has been maintained in the UK, is being increasingly substituted with propofol and, to a lesser extent, rocuronium. In 2013, a UK survey of consultant obstetric anaesthetists identified that thiopental was routinely used by 93% of respondents for induction of general anaesthesia for caesarean section [15]. In 2013 NAP5 found that 97% of obstetric GA inductions used thiopental. Our finding, that thiopental was used in just over half of participants, with propofol used in most of the others, represents a significant change in practice. Propofol use was associated with procedures other than CS, less urgent surgery, and patients with more comorbidities. However, the use of thiopental remains extremely high compared with its use within the non-obstetric surgical population [1].

The relative persistence of thiopental as the induction agent of choice in obstetrics was attributed to two main reasons; a belief that the use of thiopental was associated with a reduced risk of AAGA, and improved neonatal outcomes compared with other agents [15]. The evidence supporting these perceptions is, at best, limited with almost no adequately powered, large scale investigations [16]. Outside of the UK, there has already been a shift towards propofol as the induction agent of choice for CS under GA, most likely as a result of limited access to thiopental, as opposed to clear evidence of benefit with propofol. The debate around this subject in the UK was re-ignited by the publication of NAP5 and the UK Maternal Confidential Death Enquiries report (MBRRACE-UK) [17] by Knight et al. NAP5 reported that AAGA appeared significantly over-represented in patients who received anaesthetic induction with thiopental. Knight at al found that in some maternal deaths, the dose of thiopental (and much less often, propofol) used for induction of anaesthesia in severely ill women appeared excessive. These results support the assertion that UK anaesthetists are increasingly unfamiliar with thiopental and its continued use in obstetric practice may be causing harm. However, this should be considered alongside the impact of a dramatic reduction in the number of women who receive GA for CS [18]. It is too soon to say whether the problems highlighted by NAP5 and Knight et al are related to reduced familiarity with thiopental per se or reduced familiarity with GA in obstetric practice generally.

The use of short-acting opioids during induction of anaesthesia has increased, with 43.2% of patients in our study receiving either fentanyl, alfentanil or remifentanil at induction. NAP5 reported opioid use in only 23.4% of obstetric GAs in 2013. Opioids have traditionally been avoided as part of RSI for CS because of concerns about the potential adverse effect on the neonate, and also in the event of

failed intubation and discontinuation of anaesthesia, that they may delay the return of spontaneous ventilation in the mother. There is a paucity of data to support either of these assertions. Opioids are effective sympatholytic agents; additionally they can reduce the "induction agent – maintenance inhalational gap", which has been identified as a specific problem in GA for CS, because surgery starts so soon after induction, potentially increasing the risk of AAGA. Previous surveys have identified a disparity between opioid use in obstetric versus non-obstetric RSI, with greater use outside the obstetric setting [19]. A recent meta-analysis has shown that induction opioids (remifentanil and alfentanil, in particular) appear to be safe, with no significant effect on Apgar scores or neonatal airway intervention [20]. Research is needed to define the ideal dose and timing of opioids during GA for CS.

Our data suggest a decline in the predominance of suxamethonium in obstetric GA. In both the NAP5 (2013) and 6th National Audit Project (NAP6) activity surveys (2016), suxamethonium was used for tracheal intubation in more than 90% of obstetric patients [1,21]. In this study, it was used for only 86% of participants, even though almost all used RSI. There are indications of improvements in practice around the use of NMBDs since NAP5. In our study, reversal of neuromuscular blockade was used for 88.1% of patients who received a non-depolarising drug, an increase from 68% reversal usage identified in NAP5, but still leaving 11.9% of patients at unnecessarily increased risk of AAGA through residual blockade on emergence. Both NAP5 and the AAGBI guidelines for standards of monitoring during anaesthesia and recovery recommend using quantitative peripheral nerve stimulation monitoring to reduce this risk [22]. Just over half of the patients in this study who received NMBDs were monitored with a nerve stimulator, compared with only 38% in overall surgical patients in 2013 and 37% in 2016 [1,21]. Although suboptimal practice remains a concern, reversal and monitoring of neuromuscular blockade are more consistent with best practice guidelines in obstetric anaesthesia than for overall surgery in the UK. The role of rocuronium in obstetric anaesthetic practice has yet to be clearly defined, which perhaps explains the change in practice in one area of obstetric GA (induction agent) but not another (NMBD) [23].

A striking finding of our study was a very high incidence of difficult intubation at 1 in 18 (95% CI: 1 in 16 – 21). This is higher than previously reported by a prospective study of 1095 obstetric participants in Australia and New Zealand, which reported an incidence of 1 in 30 (95% CI: 1 in 22 – 43) [24]. Obesity was high in patients receiving GA relative to national maternity statistics and is a risk factor for difficult intubation. We found an incidence of failed intubation of 1 in 309, similar to the incidence identified in a prospective study in the UK of 1 in 224 (95% CI: 1 in 179 – 281) [4] and a meta-analysis collating data from international studies, which reported an incidence of 1 in 390 [25].

Reassuringly we found minimal adverse events as a result of this. In 2011 the 4th National Audit Report of the Royal College of Anaesthetists (NAP4) received just four reports of adverse airway events in obstetrics [26]. They extrapolated an incidence of severe airway problems of 1 in 4,348 (95% CI: 1 in 1,700 – 1 in 16,000).

The data in our study represent the largest set of prospectively collected obstetric airway management data ever reported in the UK. If our estimate of difficult airway incidence of 1 in 18 is correct, the virtual absence of use of videolaryngoscopy is a concern. There is mounting evidence on the benefits of videolaryngoscopy for obstetric airway management [27,28]. In our study, videolaryngoscopes rescued 6 of the 6 patients in whom Grade 4 direct layngoscopic views were obtained and videolaryngoscopy techniques were attempted. A UK national survey found that in contrast to main theatres, the availability of videolaryngoscopes in obstetric units was more limited (91% compared to 55%) and this must be an urgent priority for obstetric anaesthetists [29]. We did not assess the use of high flow nasal oxygenation (HFNO) in obstetrics. Although there is mixed evidence about the role of HFNO in obstetrics, it would be interesting to assess if this technique has permeated into obstetric practice [30,31].

The primary strength of this study is that it is one of the largest, prospective studies of obstetric general anaesthesia ever conducted and represents a valuable insight into current UK obstetric practice. However, this secondary study was limited by a requirement for consent in the primary study (Figure 1). This led to a higher proportion of women declining to participate, with only data from patients who specifically consented to the AAGA investigation aspect of the study included within this secondary analysis. Had we confined this to an observational study of practice, no consent would have been necessary, and we could have legitimately included greater numbers of participant data.

Conclusion

The conduct of general anaesthesia in obstetrics in England has changed since 2013. This is particularly true of the pharmacological preferences for induction of anaesthesia and neuromuscular blockade. Longer-acting NMBDs were used more often for tracheal intubation in our study than in the NAP5 activity survey. There was also increased use of neuromuscular reversal drugs and monitoring of NMBDs, both critical to minimise the risk of residual blockade and AAGA; however, current practice still falls short of the universal use advised by recent guidelines. Difficult intubation was common and the adoption of more advanced airway techniques such as videolaryngoscopy –

even perhaps to the point that this becomes the first-line technique for all – may further improve safety.

Declaration of interest

Jaideep Pandit was the clinical lead for the 5th National Audit Project (NAP5). Nuala Lucas chairs the OAA Education subcommittee and is a senior editor for the International Journal of Obstetric Anesthesia.

Funding

This work was supported by an Obstetric Anaesthetists' Association (OAA) research grant.

Collaborators

DREAMY Investigators Group:

A. A'Court, D. Abdel-Gadir, A. Abdu, C. Abisogun, Z. Aboud, J. Abrams, A. Ackerman, C. Adamson, R. Addison, A. Adeyeye, R. Adler, M. Aduse-Poku, S. Adyanthaya, N. Ahmad, D. Ahmed, A. Ahmed, B. Akindele, O. Akindele, S. Akrimi, S. Al-Rawi, Y. Ali, J. Allam, A. Allana, K. Allen, O. Allen, N. Amaradasa, L. Amarasekara, F. Amoakwa-adu, P. Anandageetha, S. Anandakrishnan, R. Anandanadesan, M. Anderson, S. Apps, A. Aquilina, G. Arbane, A. Arch, S. Armstrong, R. Arya, G. Ashiru, K. Ashpole, C. Atkinson, F. Atkinson, E. Auer, B. Avery, M. Babio-Galan, H. Bader, G. Badham, S. Bagchi, S. Bailey, Y. Baird, C. Balaka, M. Baldwin, P. Balfour, S. Bali, S. Banks, P. Barclay, L. Barnes, T. Barnes, N. Barot, S. Barrett, V. Barrett, K. Barrett, L. Bates, K. Batte, B. Baytug, M. Behravesh, S. Bell, R. Benloch, R. Bentley, J. Berg, C. Berwick, R. Berwick, R. Bhadange, S. Bhattacharyya, E. Bielskute, S. Birch, S. Bird, Ruth Bird, William Birts, Becky Black, Tatyana Blagova, Holly Blake, Oliver Blightman, Susara Blunden, R. Bolton, C. Borkett-Jones, J. Boselli, M. Bowen, R. Bowen, J. Bowyer, H. Boyle, Z. Brar, J. Bray, S. Brayshaw, C. Bressington, A. Brewer, N. Brice, L. Bridge, J. Briscoe, S. Brocklesby, H. Brown, S. Brown, D. Brunnen, K. Burijintichenna, S. Burnard, A. Burtt, V. Buswell, H. Bykar, M. Cairney, C. Calvert, L. Camarasa, N. Campbell, F. Campbell-Jones, J. Cantliffe, W. Carrol, J. Carvalho, C. Cashell, S. Cassie, K. Cassim, M. Chandler, R. Chapman, R. Charles, P. Chen, D. Cheyne, K. Chima, F. Chin, R. Chirvasuta, M. Shao Chong, S. Choudhury, P. Chowdhury, T. Christmas, S. Chughwani, S. Ciechanowicz, E. Clarey, R. Coe, J. Cohen, N. Coker, K. Collins, L. Collis, J. Comar, M. Conroy, K. Constantin, J. Corfe, E. Coulborn, V. Cowie, R. Crone, J. Cronin, J. Crooks, N. Crowther, E. Crowther, C. Cruz, A. Curtis, S. Curtis, S. Curtis, A. Dabrowicz, N. Daines, V. Dalal, P. Dannatt, D. Das, J. Dash, K. Davidson, S. Davies, Y. Davis, J. Dawson, J. Dean, C. Dean, J. Denman, N. Desai, P. Dewan, S. Dimont, C. Donovan, M. Doraiswami, K. Doughty, J. Douglass, M. Dower, S. Downing, W. Duberry, E. Duckham, L. Dudgeon, S. Dukes, L. Dunn, V. Duraiswamy, A. O' Dwyer, K. Dyer, S. Eapen, M. Earl, S. Eason, K. Edwards, Z. Edwards, O. Egole, J. Ekpa, O. El-Amin, K. El-Boghdadly, O. Elbasir, J. Eldridge, L. Elgie, M. Ellington, K. Elliott, J. Elliott, M. Elmi, R. Elnoumeir, E. Emeakaraoha, M. Evans, M. Everett, P. Fabb, H. Farooq, R. Farrimond, F. Faulds, E. Fawcett, A. Feneley, D. Fernando, J. Ferns, C. Finlay, S. Fitzgerald, D. O'Flaherty, M. Fleet, L. Fletcher, V. Fludder, T. Follet, J. Forbes, M. Forth, G. Foster, J. Francis, K. Fraser, L. Friedman, L. Fruggeri, L. Fulton, S. Funnell, A. Gadre, A. Gandhi, H. Gardiner, Z. Garner, G. Garvey, T. Gately, R. George, S. Gillespie, S. Glover, J. Goddard, B. Goodman, T. Gopal, G. Graham, D. Green, D. Griffin, J. Griffith, S. Grigsby, J. Grindey, H. Griffiths, J. Groome, C. Grother, G. Grounds, A. Groves, A. Guha, A. Gunawardhana, A. Gupta, R. Gupta, J. Gutsell, R. Haddon, D. Hadi, N. Hadjipavlou, H. Hammerbeck, L. Hammon, S. Hammond, H. Hampanna, H. Hancock, H.

Handapangoda, Y. Haroon-Mowahed, D. Harpham, G. Harris, A. Harrison, D. Harshan, A. Hartopp, E. Harty, N. Haslam, G. Hawkins, E. Hawkins, S. Hawksey, C. Hays, T. Hazelton, A. Heavyside, C. Hemeson, K. Henderson, O. Henry, L. Herbert, N. Higgins, J. Hilton, C. Hindmoor, R. Hitchcock, L. Hobbs, M. Homsy, C. Honeywell, N. Hoque, K. House, R. Howle, A. Tiller, M. Huniak, J. Hunte, T. Husain, C. Huson, C. Hussain, T. Hussain, Z. Hussein, J. Hyams, E. Hyde, M. Laverdino, A. Ignacka, E. Innes, S. Ioannidis, R. Iqbal, F. Ismail, J. Jackson, M. Jackson, G. Jackson, R. Jacobs, P. Jadhav, A. Jalaly, L. James, M. James, S. Jani, C. Jeganathan, C. Joannides, R. Johnson, T. Johnson, C. Johnston, R. Jones, T. Jones, M. Kadr, R. Kainth, J. Kane, R. Kanji, S. Kannanparambil, G. Kar, T. Kasianandan, H. Kaskos, L. Kavanagh, R. Kaye, L. Kelliher, S. Kelliot, J. Kelly, J. Kelly, C. Kenyon, L. Kessack, S. Kestner, M. Khaku, S. Khaleeq, P. Khan, S. Khan, U. Kidwai, C. King, H. King, E. Kingston, W. Kok, R. Konig, Z. Konstantinova, P. Krishnan, J. Kua, K. Kuntumalla, E. Kursumovic, K. Kurzatkowski, H. Kuttambakam, K. Lane, S. Lane, A. Langton, H. Latif, N. Lau, S. Laxman, H. Laycock, R. Lee, S. Leonardi, K. Light, H. Lightfoot, S. Liu, S. Liyanage, J. Lowe, N. Lucas, M. Lungu, M. Lunn, H. Lynes, K. Machavarapu, M. Mackenzie, D. Magee, J. Major, V. Male, Z. Malik, K. Manso, M. Maquinana, K. Marciniak, L. Maronge, C. Marsh, C. Martella, N. Martin, N. Martins, J. Marway, L. Mason, L. Mason, N. Masood, J. Masters, M. Maton-Howarth, F. Mazzola, T. McAllister, R. McCarthy, C. McCormick, S. McCready, S. McDougall, L. Mcewan, J. McGarry, H. McKevitt, S. Mckinley, A. Mckskeane, E. McMaster, M. McMonagle, H. McNamara, H. McPhee, L. McRae, D. Mead, E. Meadows, M. Mehta, J. Meikle, Y. Metodiev, C. Michael, V. Millar, S. Miller, G. Miller, S. Milne, K. Miltsios, L. Misquita, S. Misquita, M. Mittal, M. Mohamed, K. Powell Monaghan, J. Monk, A. Monkhouse, D. Monks, L. Montague, A. Moon, J. Moran, A. Moreton, E. Morgan, O. Morgan, D. Morland, M. Morosan, K. Morris, A. Morris, C. Moser, M. Mount, C. Muir, M. Mupudzi, M. Murali, I. Murdoch, H. Murray, T. Murray, K. Murrell, G. Narasimha Murthy, D. Neeley, H. Nei, K. Neil, T. Nejim, M. Nel, A. Nicholson, A. Nicklin, C. Nolan, T. Nolan, E. Nurmi, B. O'Neill, C. Oakes, N. Oakes, M. Ochoa-Ferraro, N. Odeleye, K. Oliver, M. Oliver, J. Onslow, D. Onwochei, T. Oommen, T. Orr, O. Osagie, H. Osborn, J. Overend, H. Owston, E. Pack, P. Padhi, P. Palani, R. Pandey, D. Pandya, N. Panesar, C. Papageorgiou, G. Papanastasiou, C. Papoutsos, S. Pararajasingham, J. Parry, H. Patel, H. Patel, J. Patel, K. Patel, K. Patel, M. Patel, R. Patel, R. Patel, N. Patel, S. Pathak, F. Pearson, V. Peciulene, B. Peers, B. Peirce, S. Pepper, J. Perinpanayagam, H. Perry, N. Petrova, T. Phillips, S. Phillips, L. Phylactides, F. Pilkington, J. Plumb, E. Poimenidi, A. Sau Kuk Poon, T. Potter, U. Poultney, L. Powell, A. Prenter, K. Preston, A. Price, N. Pritchard, J. Pullen, M. Purohit, C. Quamina, J. Qureshi, Z. Rajput, S. Ramage, T. Ramanathan, U. Ranasinghe, K. Ranatunga, A. Rand, S. Randive, D. Rangarajan, C. Rao, S. Rao Pelluri, A. Ratnasingham, J. Razzaque, A. Reddy, K. Redington, E. Reel, P. Remeta, F. Ricco, A. Riccoboni, P. Rice, M. Rich, N. Richards, J. Riches, S. Ripoll, F. Roberts, K. Roberts, K. Robins, S. Robinson, S. Roche, M. Rojo, N. Carmela Romano, H. Rosser, L.

Roughley, C. Routley, C. Rowley, P. Rudra, R. Russell, C. Ryan, C. Saad, A. Sadeghi, A. Salberg, V. Salota, M. Samuel, R. Samuels, S. Sanapala, S. Sanusi, S. Sarao, S. Sathyabhama, Z. Saunders, B. Sawarzynska-ryszka, P. Sceales, N. Schumacher, N. Schwartz, C. Sellers, H. Sellers, J. Sellick, S. Sen, D. Senaratne, S. Senbeto, D. Seneviratna, T. Setty, R. Shah, S. Shah, J. Shambly, S. Sharafudeen. I. Sharieff, L. Sharifi, L. Sharpe, M. Shaw, I. Sheldrake, P. Shinde, A. Shonfeld. J. Short, J. Siah, S. Sibug. O. Siddique, S. Siew, M. Simpson, G. Singleton, K. Sinha, A. Sinha, M. Sinnott, H. Sivadhas, S. Sivakumar, B. Sivarajan, S. Sivarajan, C. Skeoch, S. Slade, P. Slater, C. Smith, C. Smith, C. Smith, E. Smith, J. Smith, L. Smith, A. Smith, E. Smith, R. Smith, S. Smith, T. Smith, H. Smithers, S. Smolen, C. Smyth, T. Snel, C. Snipe, S. Soltanifar, N. Sonawane, A. Soundararaja, E. Spence, M. Spiliopoulos, C. Srivastava, K. Stacey, H. Stafford, N. Staines, R. Stead, E. Stevens, A. Stilwell, G. Stocks, A. Stokes, C. Stone, B. Straughan, V. Subbarathnam, S. Sudunagunta, P. Sultan, P. Suppiah , P. Surve , A. Sutherland, R. Swanton, C. Swarbrick, A. Swinson, E. Syrrakou, S. Tadbiri, P. Tamhane, P. Tamilselvan, A. Tan, S. Tanna, H. Tarft, L. Tarry, I. Taylor, S. Taylor, J. Tebbot, S. Theron, M. Thomas, S. Todd, H. Tolliday, C. Topham, N. Tovell, M. Traves, D. Trodd, A. Tufchi, K. Turley, M. Turnbull, C. Turnbull, O. Turner, W. Turner, S. Turney, E. Tyagi, D. Uncles, V. Unsworth, P. Vadnere, R. Varadan, V. Vasishta, A. Veal, L. Vedham, J. Venkaya, M. Verghese, I. Veronica, D. Vidanagamage, R. Vincent, V. Vyapury, H. Wain, F. Walbridge, E. Walker, P. Walsh, E. Walshe, M. Walters, Y. Wan, C. Wang, K. Wankhade, G. Waters, C. Watts, A. Webber, T. Wedgwood, M. Wee, S. Wellstead, A. White, M. Whitear, L. Whitefield, S. Wilkinson, L. Williams, R. Williams, D. Wilson, S. Wilson, K. Wimble, E. Winkley, L. Winslow, P. Winwright, K. Wloch, G. Wong, H. Wong, J. Man Wong, T. Wood, S. Wray, I. Wrench, J. Wu, K. Wynn, Y. Yap, C. Kuan Yeow, E. Young, A. Yusaf, S. Uz Zafar, D. Zeinali, S. Zhang, S. Zope, L. Zucco.

Pan-London Perioperative Audit and Research Network (PLAN):

S. Anwar, N. Blunt, J. Cronin, K. El-Boghdadly, V. Grover, K. Grailey, M. Gray, D. Highton, P. Hopkins, C. Johnston, H. Kemp, H. Laycock, Q. Lo, D. Martin, C. Morkane, J. O'Carroll, C. Oliver, M. Patel, S. Phillips, B. Post, A. Visram, A. Wickham.

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Tables

Characteristic	All patients (n= 3115)	National data for maternity patients	National data source
Age (years)	31.5 (6.1)	30.5 (5.5)	ONS*; 2017; England and Wales; n = 679,106
Weight (kg)	70 (60.8 – 84 [38 – 188])	N/A	ONS*; 2017; England; n = 451,929
BMI (kg.m$^{2)}$	27.7 (6.1)	N/A	MSDS†; 2018; England; n = 398,026
<18.5	53 (1.7%)	N/A	
≥18.5 <25	978 (31.4%)	45.8%	
≥25 <30	716 (23.0%)	26.5%	
≥30	737 (23.7%)	20.6%	
≥35	338 (10.9%)	5.0%	
Unknown	293 (9.4%)	-	
Parity			MSDS†; 2018; England; n = 398,026
1	1842 (59.1%)	41.7%	
2	724 (23.2%)	35.4%	
3	290 (9.3%)	14.0%	
≥ 4	214 (6.9%)	8.7%	
Unknown	45 (1.4%)	-	
ASA PS score		N/A	N/A
1	1219 (39.1%)		
2	1598 (51.2%)		
3	205 (6.6%)		
≥ 4	11 (0.4%		
Unknown	82 (2.8%)		

Table 1. Baseline characteristics of included patients, all of whom received general anaesthesia for obstetric surgery. Results are presented as mean (SD), median (IQR [range]) and percentage values, as appropriate. Weights were recorded at time of pregnancy booking appointment. ASA PS = American Society of Anesthesiologists Physical Status score; healthy pregnant women were defined as ASA PS 1 for the purposes of this study. *Data source is Office for National Statistics 2017: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsbyparentscharacteristics. †Data source is NHS Digital Maternity Services Dataset 2017-2018: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-sets/maternity-services-data-set

Characteristic		CS surgery (n = 2554)	Non-CS surgery* (n = 563)	Total (n=3117)
Urgency of surgery	Emergency / Category 1	1329 (52.0%)	307 (54.5%)	1636 (52.5%)
	Urgent / Category 2	676 (26.5%)	139 (24.7%)	815 (26.1%)
	Expedited / Category 3	159 (6.2%)	19 (0.6%)	178 (5.7%)
	Elective / Category 4	375 (14.7%)	12 (3.3%)	387 (12.4%)
	Unknown	15 (0.6%)	86 (15.3%)	101 (3.2%)
Start of GA relative to surgical start	De novo	1708 (66.9%)	494 (87.7%)	2202 (70.6%)
	Conversion from neuraxial anaesthesia to GA after initial surgical incision	809 (31.6%)	52 (9.2%)	861 (27.6%)
	Unknown	37 (1.4%)	17 (3.0%)	54 (1.7%)
Indication	Clinical urgency (e.g. threat to life of mother or neonate)	1279 (50.1%)	345 (61.3%)	1624 (52.1%)
	Maternal preference (e.g. anxiety)	242 (9.5%)	66 (11.7%)	308 (9.9%)
	Neuraxial block contraindicated (e.g. thrombocytopenia, sepsis)	333 (13.0%)	130 (23.1%)	463 (14.9%)
	Failed neuraxial block (e.g. unable to site neuraxial block, inadequate or early receding sensory block height)	751 (29.4%)	51 (9.1%)	802 (25.7%)
	High neuraxial block (e.g. total spinal or patient distress from high block)	18 (0.7%)	4 (0.7%)	22 (0.7%)
	Other (e.g. prolonged surgery, indicated for surgical procedure)	86 (3.4%)	39 (6.9%)	125 (4.0%)
	Unknown	27 (1.1%)	10 (1.8%)	37 (1.2%)

Table 2. Urgency and indication for general anaesthesia and surgery for obstetric patients. Multiple indication for GA were permissible, hence the total exceeds the number of participants.

* Exploration under anaesthesia (EUA) = 38.0%; manual removal of placenta (MROP) = 35.8%; Other = 26.2%.

Characteristic		CS surgery (n = 2554)	Non-CS surgery (n = 563)	Total (n=3117)
Induction hypnotic drug	Thiopental	1431 (56.0%)	218 (38.7%)	1649 (52.9%)
	Propofol	1093 (42.8%)	326 (57.9%)	1419 (45.5%)
	Ketamine	9 (0.4%)	19 (3.4%)	28 (0.9%)
	Unknown	18 (0.7%)	0 (0%)	18 (0.6%)
Neuromuscular blocking drug for tracheal intubation	Suxamethonium	2158 (84.5%)	473 (84.0%)	2631 (84.4%)
	Rocuronium	292 (11.4%)	75 (13.3%)	367 (11.8%)
	Atracurium	50 (2.0%)	9 (1.6%)	59 (1.9%)
	Unknown	54 (2.1%)	6 (1.1%)	60 (1.9%)
Opioid use during GA induction	None	1623 (63.5%)	143 (25.4%)	1766 (56.7%)
	Fentanyl	487 (19.1%)	314 (55.8%)	801 (25.7%)
	Alfentanil	411 (16.1%)	103 (18.3%)	514 (16.5%)
	Remifentanil	33 (1.3%)	3 (0.5%)	36 (1.2%)
Maintenance anaesthetic agent	Sevoflurane	2141 (83.8%)	457 (81.2%)	2598 (83.3%)
	Isoflurane	251 (9.8%)	54 (9.6%)	305 (9.8%)
	Desflurane	80 (3.1%)	17 (3.0%)	97 (3.1%)
	Total intravenous anaesthesia	18 (0.7%)	5 (0.9%)	23 (0.7%)
	Unknown	63 (2.5%)	30 (5.3%)	90 (2.9%)
Nitrous oxide use during GA maintenance	Nitrous oxide	1259 (49.3%)	267 (47.4%)	1526 (49.0%)
Post-operative destination	Delivery suite or post-natal ward (level 0)	1722 (67.4%)	256 (45.4%)	1978 (63.5%)
	Obstetric high dependency care unit (level 1-2)	756 (29.6%)	264 (46.9%)	1020 (32.7%)
	General intensive care unit (level 2-3)	44 (1.7%)	26 (4.6%)	70 (2.2%)
	Unknown	32 (1.3%)	17 (3.0%)	49 (1.6%)
Time of GA induction	2000 – 07:59 (i.e. night shift)	1117 (43.7%)	266 (47.3%)	1383 (44.4%)

Table 3. Summary of selected general anaesthetic (GA) and surgical characteristics for all obstetric surgery, caesarean section (CS) sand non-CS surgical procedures only.

Grade of direct laryngoscopy	All (n = 3117)	Difficult intubation (n = 155)	Failed intubation (n = 10)
1	2355 (75.6%)	34 (21.9%)	0 (0%)
2a	382 (12.3%)	29 (18.7%)	0 (0%)
2b	147 (4.7%)	38 (24.5%)	4 (40.0%
3	68 (2.2%)	45 (29.0%)	2 (20.0%)
4	10 (0.3%)	8 (5.2%)	2 (20.0%)
Unknown	155 (5.0%)	1* (0.6%)	2* (20.0%)

Table 4. Modified Cormack and Lehane laryngoscopic view obtained by direct laryngoscopy and airway outcome. *Videolaryngoscopy only used, hence no direct laryngoscopy grade obtained.

Legends to figures

Figure 1. STROBE flowchart of participant recruitment.

Figure 2. Summary of selected general anaesthetic characteristics. Data are total number of participants.

Figure 3. Geographic distribution of induction hypnotic drug use for general anaesthesia according to Health Education England anaesthetic training regions in (A) England and (B) Greater London. Size of each plot represents the proportional number of participants originating within the corresponding region. Since Greater London represented 39.8% of all participating hospitals and 41.9% of all participants the region has been plotted separately.