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Secondary analysis of outcomes after 11,085 hip fracture operations from the prospective UK Anaesthesia Sprint Audit of Practice (ASAP-2)

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Summary

We re-analysed prospective data collected by anaesthetists in the Anaesthesia Sprint Audit of Practice (ASAP-1) to describe associations with linked outcome data. Mortality was 165/11,085 (1.5%) 5 days and 563/11,085 (5.1%) 30 days after surgery and was not associated with anaesthetic technique (general vs. spinal, with or without peripheral nerve blockade). The risk of death increased as blood pressure fell: the odds ratio (95% CI) for mortality within five days after surgery was 0.983 (0.973–0.994) for each 5 mmHg intra-operative increment in systolic blood pressure, p = 0.0016, and 0.980 (0.967–0.993) for each mmHg increment in mean pressure, p = 0.0039. The equivalent odds ratios (95% CI) for 30-day mortality were 0.968 (0.951–0.985), p = 0.0003 and 0.976 (0.964–0.988), p = 0.0001, respectively. The lowest systolic blood pressure after intrathecal local anaesthetic relative to before induction was weakly correlated with a higher volume of subarachnoid bupivacaine: r^2 −0.10 and −0.16 for hyperbaric and isobaric bupivacaine, respectively. A mean 20% relative fall in systolic blood pressure correlated with an administered volume of 1.44 ml hyperbaric bupivacaine. Future research should focus on refining standardised anaesthesia towards administering lower doses of spinal (and general) anaesthesia and maintaining normotension.

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Introduction

There is currently a dearth of high quality, prospective evidence to support particular anaesthetic practices for patients with hip fracture. Randomised trials in the peri-operative period are difficult to perform [1] and observational studies are mostly retrospective case series with significant data omissions [2–5] or concerns about data quality [6].

The National Hip Fracture Database (NHFD) collects high-quality observational data from more than 95% of all new cases of hip fracture in the UK (except Scotland) [7], which can be audited against national standards and inform future research into care quality improvement [8]. The Anaesthesia Sprint Audit of Practice (ASAP) project was a national snapshot audit embedded within NHFD, that tasked anaesthetists with collecting specific anaesthesia and peri-operative variables for patients undergoing hip fracture surgery. The initial ASAP report (ASAP-1) was published in March 2014 [9]. In common with previous reports of national audits [6, 10], ASAP-1 found 'striking' inter-hospital variation in anaesthesia care, reflecting the uncertainties about what methods of anaesthesia might provide the best outcome for older, frailer patients with comorbidities requiring surgical hip fracture repair.

By revisiting the data collected for ASAP-1 and linking it to outcome data held by the NHFD, this pre-planned study (ASAP-2) aimed to determine whether there were any statistically significant associations between peri-operative patient factors, anaesthetic factors and outcomes.

Methods

The background and methods used to collect the ASAP-1 audit data are described on pages 9-11 of the Report [9]. The Integrated Research Application System ethics committee approved this study through the proportionate review mechanism. The Confidentiality Advisory Group of the Health Research Authority and the Royal College of Physicians Falls and Fragility Fractures Audit Programme approved the transfer of encrypted, password-protected, anonymised data to a double password-protected NHS e-mail account for analysis.

We recorded patient variables on hospital admission: age; sex; comorbidities; ASA physical status; place of residence (home, sheltered, rehabilitation, residential home, nursing home, inpatient, other); independence (self-caring/home-help/sheltered/residential/nursing); and cognition (abbreviated mental test score) [11]. We recorded the dates and times of hospital admission and surgery; the type of anaesthesia administered (general, nerve block, spinal); the type and quantity of intrathecal injectate; the seniority of operative surgical and anaesthetic personnel; intra-operative blood pressures; and signs of bone cement implantation syndrome. We measured postoperative cognition and residential destination on discharge.

We calculated the Nottingham Hip Fracture Score for all patients [12–16], with which we adjusted outcomes for patient age, cognitive function, residential status and comorbidities. We determined patient survival at 30 postoperative days from the NHFC, cross-referenced with data from Egton Medical Information Systems Ltd (Leeds, UK). We also recorded mortality 5 days after hospital admission. We defined the postoperative length of stay as the time from surgery to discharge from the acute hospital.

We analysed systolic and diastolic blood pressures at two times: immediately before commencement of anaesthesia; and the lowest recorded intra-operative value. We calculated the mean arterial blood pressure as the diastolic pressure plus one-third of the difference between systolic and diastolic pressures. We analysed relative changes in systolic and mean arterial blood pressures between these two times.

We analysed mortality rates with Fisher's exact tests and chi-squared tests, as appropriate, with test p values < 0.05 followed by adjusted Wilcoxon pairwise tests [17]. Sensitivity analysis was performed by allocating the general plus spinal anaesthesia to either the general anaesthesia or spinal anaesthesia groups.

We analysed the duration of hospital stay with the Wilcoxon test. Adjustment for Nottingham Hip Fracture Score was performed using stratified Mantel–Haenszel tests. We used logistic regression, with and without adjustment for the Nottingham Hip Fracture Score to test the association between the lowest intra-operative blood pressure and mortality at five and 30 postoperative days. We calculated the mortality odds ratios for different ranges of blood pressures, measured before induction of anaesthesia and for different ranges of the lowest intra-operative blood pressures. The odds ratios were calculated for individual blood pressure ranges and for all blood pressures below the threshold for each range [1]. We considered a two-sided p value < 0.05 statistically significant. We used SPSS Version 17.0 (SPSS Inc., Chicago, IL, USA) and R statistical package (The R Project for Statistical Computing, http://www.R-project.org/).

Results

The NHFD recorded 16,904 operations between 1st May and 31st July 2013, of which 11,130 (67.5%) were audited [9]. After identifying 45 duplicate records, we analysed 11,085 records for this study. The proportion of cases for which the anaesthetic technique was categorised identically by the National Hip Fracture Database and the ASAP data collectors ranged from 35% for general anaesthesia to 88% for general anaesthesia supplemented by epidural, peripheral nerve or surgical site injection of local anaesthetic.

There were no differences in postoperative outcomes between different anaesthetic techniques (Tables 1 and 2), with or without stratification by the Nottingham Hip Fracture Score. The absence of an association of outcome with anaesthetic technique was unchanged when combined general and spinal anaesthesia was categorised as 'general anaesthesia' or 'spinal anaesthesia'. There were no differences in 30-day mortalities reported by the NHFD vs. the audited dataset: spinal anaesthesia 4.6% vs. 4.7%, p = 0.77; general anaesthesia 5.4% vs. 5.3%, p = 0.96. We calculated that the 30-day postoperative mortality for patients recorded by the NHFD but not audited in ASAP (4,023 after exclusion of Northern Ireland hospitals, for whom mortality data were unavailable) was 8.9%.

Table 1 Five and 30-day postoperative mortalities, and length of postoperative inpatient stay in survivors to discharge, by type of anaesthesia: 'Both' general anaesthesia and spinal anaesthesia; 'With block' includes peripheral nerve block, epidural or local anaesthetic infiltration. Values are number (proportion) or median (IQR [range]).

	General anaesthesia			Spinal anaesthesia			
Outcome	**Alone (n = 985)**	**With block (n = 4,364)**	**Both (n = 458)**	**Alone (n = 1,506)**	**With block (n = 3,234)**	**Unknown (n = 538)**	**p value**
Mortality							
5-day	13 (1.3%)	70 (1.6%)	6 (1.9%)	29 (1.9%)	36 (1.1%)	11 (2.0%)	0.25
30-day	53 (5.4%)	238 (5.5%)	18 (3.9%)	87 (5.8%)	137 (4.2%)	30 (5.6%)	0.14
Hospital stay							
Patients analysed	883 (89.6%)	3,729 (85.4%)	458 (100.0%)	1,319 (87.6%)	2,902 (89.7%)	487 (90.5%)	
Length of stay; days	13.2 (8.0–23.4 [1.3–165.8])	13.3 (8.1–23.3 [1.0–203.2])	12.1 (7.0–20.2 [1.0–120.7])	13.2 (8.3–22.1 [0.2–224.0])	13.2 (8.0–22.8 [0.2–287.9])	13.4 (8.2–24.3 [0.3–287.9])	0.50

Table 2 Deterioration in cognition (abbreviated mental test score), residential status and dependency for Anaesthesia Sprint Audit of Practice-2 patients after surgical repair of hip fracture compared with pre-operative values, categorised by type of anaesthetic (general vs. other, with or without peripheral nerve blockade, epidural or infiltration) and by whether a spinal anaesthetic was supplemented with sedation. Values are number (proportion).

	Type of anaesthesia			
		Spinal		
	General	With sedation	Without sedation	p value
Deterioration in				
Cognition	1,161/5,004 (23.2%)	823/3,563 (23.1%)	145/659 (22.0%)	0.77* and 0.58†
Residential status	2,794/5,895 (47.4%)	2,369/4,845 (48.9%)		0.11
Independence	1,804/5,745 (31.4%)	1,523/4,730 (32.2%)		0.57

p value for *general vs. spinal and for †spinal with vs. without sedation.

The start time of operations and the grade of the most senior surgeon and anaesthetist present was recorded for 10,286 (92.8%) operations. Patients cared for by a combination of consultant or specialist surgeon and anaesthetist were on average one year younger (than patients cared for by other grades) but more often were ASA physical status 4 or 5: median (IQR [range]) age 83 (76–88 [24–104]) years vs. 84 (77–89 [30–104]) years, respectively; 738/5,596 (13.2%) vs. 547/5,155 (10.6%) respectively, $p < 0.0001$ for both. There were no differences in outcomes between patients cared for by consultant or specialist surgeon and anaesthetist compared with other grades: 5-day and 30-day postoperative mortalities, 1.4% vs. 1.5%, $p = 0.89$ and 5.0% vs. 5.0%, $p = 0.95$, respectively; return home 51.9% vs. 53.2%, $p = 0.23$. Survivors spent 0.7 days (17 h) less in hospital after surgery by a combination of consultant or specialist surgeon and anaesthetist, compared with other grades, median (IQR [range]) 13.0 (8.0–22.1 [0.2–287.9]) days vs. 13.7 (8.1–24.0 [0.1–192.2]) days, respectively, $p = 0.0023$.

The combination of consultant or specialist surgeon and anaesthetist was present at operations between 17.01–07.59 less often than other grades: 220/5,767 (3.8%) vs. 358/5,319 (6.7%), $p < 0.0001$. However, there was no significant difference in mortality between patients undergoing surgery 08.00–17.00 compared with 17.01–07.59: 5-day 43/2,858 (1.5%) vs. 108/7,428 (1.5%) respectively, $p = 0.92$; and 30-day 143/2,858 (5.0%) vs. 371/7,428 (5.0%) respectively, $p = 0.99$. Fewer patients underwent surgery on weekends, 08.00 Saturday – 08.00 Monday (101.day^{-1}), compared with weekdays (116.day^{-1}), but the 30-day postoperative mortalities were similar, 145/2,615 (5.5%) vs. 378/7,520 (5.0%), respectively, $p = 0.33$.

We analysed the association between postoperative mortality and systolic blood pressure changes and mean arterial blood pressure changes for 10,489 and 10,302 patients, respectively. We did not analyse peri-operative blood pressure changes from 23 patients who had cardiovascular collapse requiring cardiopulmonary resuscitation associated with bone cement implantation syndrome [18]. Mortality at five and 30 postoperative days was associated with lower intra-operative blood pressures (Fig. 1a–d). The OR (95% CI) for 30-day mortality was 0.992 (0.986–0.998) for each 5 mmHg increase in systolic pressure, $p = 0.0075$, and 0.985 (0.977–0.992) for each mmHg increase in mean pressure, $p < 0.0001$. Similar relationships were seen for five-day mortality odds ratios (95% CI): mean blood pressure 0.968 (0.951–0.985), $p = 0.0003$; systolic blood pressure 0.976 (0.964–0.988), $p = 0.0001$. These relationships persisted when adjusted for Nottingham Hip Fracture Score in 8,272 patients with complete data. The OR (95% CI) for 30-day mortality was 0.994 (0.988–0.994) for a 5 mmHg increase in systolic blood pressure, $p = 0.0016$, and 0.990 (0.982–0.997) for each mmHg increase in mean pressure, $p = 0.030$. Similarly, the OR (95% CI) for five-day mortality was 0.983 (0.973–0.994) for a 5 mmHg increase in systolic blood pressure, $p = 0.0016$, and 0.980 (0.967–0.993) for each mmHg increase in mean pressure, $p = 0.0039$. An intra-operative systolic blood pressure below 85 mmHg compared with higher systolic pressures was associated with higher

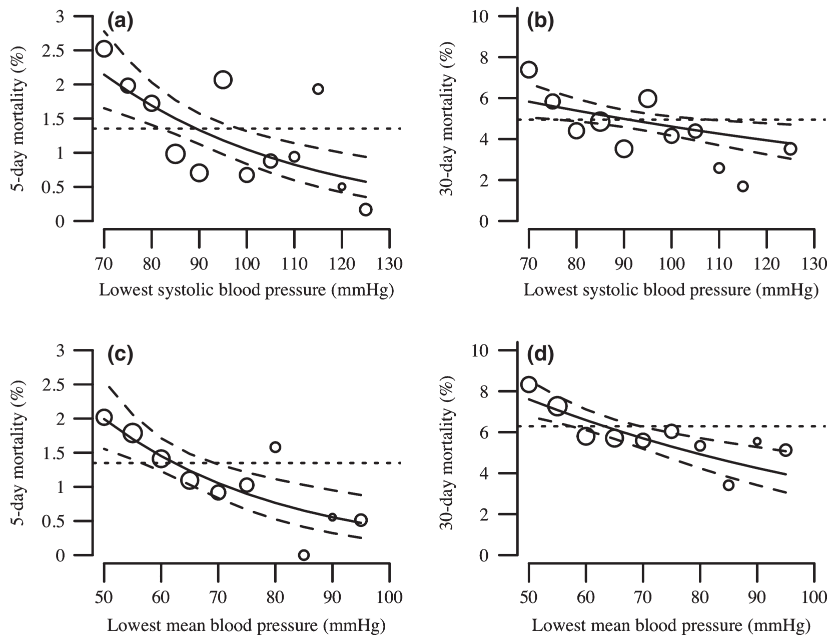

Figure 1 The association of lowest intra-operative systolic (a and b) and mean (c and d) arterial blood pressures with mortality five (a and c) and 30 (b and d) days after hip fracture surgery. The overall mortality is shown for reference. The individual point areas are proportional to group size.

mortalities: five-day mortality 64/3,062 (2.1%) vs. 78/7,427 (1.1%) respectively, p = 0.017; 30-day mortality 181/3,062 (5.9%) vs. 338/7,427 (4.6%) respectively, p = 0.013. An intra-operative mean arterial blood pressure below 75 mmHg compared with higher pressures was similarly associated with higher mortalities: five-day mortality 120/8,163 (1.5%) vs. 19/2,139 (0.9%) respectively, p = 0.049; 30-day mortality 415/8,163 (5.1%) vs. 94/2,139 (4.4%) respectively, p = 0.0029. Mortalities at five and 30 postoperative days were increased in 5 mmHg strata of blood pressure compared with higher pressures. The five-day and 30-day mortality rates for the 71–75 mmHg systolic blood pressure stratum were 18/908 (2.0%) and 53/908 (5.8%) compared with 96/8,375 (1.1%) and 384/8,471 (4.5%) for higher systolic pressures, p = 0.038 and 0.00020, respectively. The five-day and 30-day mortality rates for the 51–55 mmHg mean blood pressure stratum were 31/1,702 (1.8%) and 95/1,733 (5.5%) compared with 76/6,908 (1.1%) and 314/6,670 (4.7%) for higher mean pressures, p = 0.023 and 0.087, respectively. The 30-day mortality for the lowest stratum of mean blood pressure (< 51 mmHg) was significantly more than for higher mean blood pressures, 100/1,585 (6.3%) vs. 409/8,717 (4.7%), p = 0.0080.

We calculated the association of relative changes in systolic blood pressure with volumes of spinal bupivacaine 0.5% (hyperbaric for 2,972 patients and isobaric for 956 patients). The relative fall in systolic blood pressure was weakly correlated with more subarachnoid bupivacaine: r^2 −0.10 and −0.16 for hyperbaric and isobaric bupivacaine, respectively. A 20% relative fall in systolic blood pressure correlated with 1.4 ml hyperbaric bupivacaine 0.5% (Fig. 2a) and 1.5 ml isobaric bupivacaine 0.5% (Fig. 2b). Quantile regression analysis, offset for variation not associated with spinal injectate, confirmed a significant association between the median relative reduction in systolic blood pressure and the dose of spinal hyperbaric bupivacaine 0.5%: the median (95% CI) relative fall in blood pressure was 31% (10–53%) after 1.5 ml and 36% (12–55%) after 2.5 ml.

Discussion

We found no association between anaesthetic technique and mortality after surgery for hip fracture. We found no association between day of the week, time of day or grade of surgical or anaesthetic personnel with mortality. Mortalities five days and 30 days postoperatively were associated with lower intra-operative blood

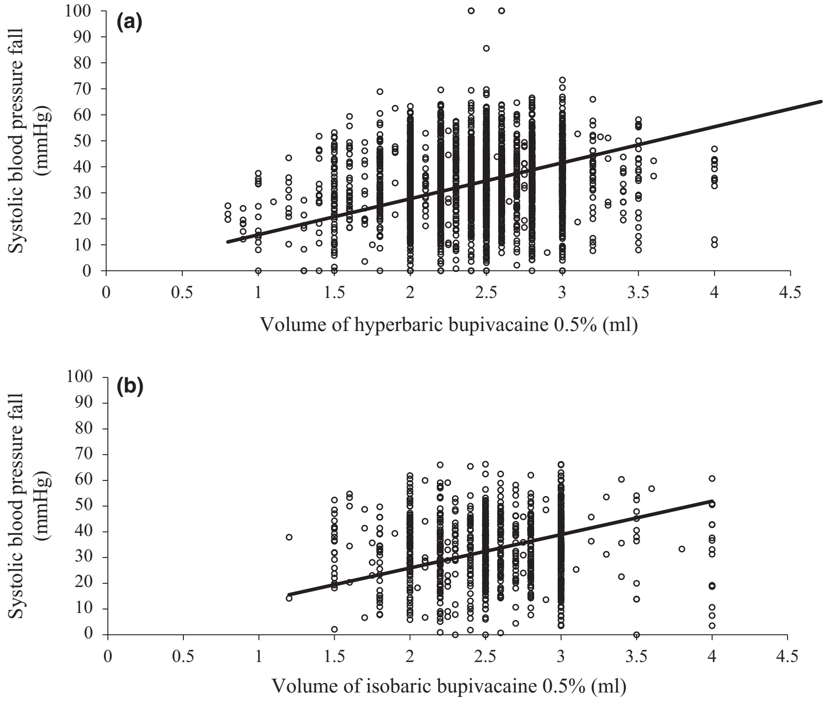

Figure 2 The reduction in systolic blood pressure following intrathecal injections of different volumes of (a) hyperbaric and (b) isobaric bupivacaine 0.5% in Anaesthesia Sprint Audit of Practice-2 patients having surgical repair of hip fracture.

pressures. Lower intra-operative blood pressures were weakly associated with higher volumes of intrathecal local anaesthetic.

This study has several strengths in comparison to previous observational studies [2–6]: it was conducted prospectively; it captured data about large numbers of patients (~ one-fifth of all hip fractures in England, Wales and Northern Ireland annually); and data-point completion rates were high (> 90% for most fields). Importantly, data about anaesthesia were collected by anaesthetists and so are likely to provide a far more accurate indication of actual interventions than retrospective data about anaesthesia collected by non-anaesthetists [19]. Such discrepancy in data accuracy is suggested by a concordance of only 35–88% between the type of anaesthesia as recorded by NHFD data collectors and that contemporaneously collected by ASAP anaesthetists.

There are weaknesses with the study that need to be borne in mind when interpreting the results. Data were only collected for 67.5% of patients who fractured their hip(s) during the three-month study period, and the primary outcome for these, 30-day mortality, was 36% lower than the annual 2014 figure reported by the NHFD (5.1% vs. 8.0%) [7]. Although there appears to be some seasonal variation affecting mortality, we calculated that the 23 (12.5%) eligible hospitals who did not participate in ASAP had a 75% higher overall 30-day mortality rate (8.9% vs. 5.1%) during the study period, data from which would have been very useful in determining the risks and benefits of various anaesthetic interventions more accurately. Similarly, incomplete patient data submitted to ASAP may have affected the statistical significance of some findings, although the proportion of these was small (e.g. 1.8% for mortality by type of anaesthesia). More importantly, it should be remembered that this is an observational study and so any statistically significant findings can only indicate association rather than causation. In this vein, although there was any number of comparisons that could have been analysed, we avoided small subgroup analysis and potentially unreliable interpretations of significance based on these.

Anaesthesia Sprint Audit of Practice-2 confirms that there appears to be no significant difference between ‘general anaesthesia’ and ‘spinal anaesthesia’ in terms of five- or 30-day mortality after hip fracture surgery. This supports a previous suggestion of ours that any future randomised controlled trial looking at the same is unlikely to find any difference, or, given the numbers of patients involved in ASAP-2, would have to be of such a size as to make it very challenging to fund [1]. We re-iterate our previous suggestion [1] that any future randomised controlled trials will need to define anaesthetic technique more specifically than 'general' or 'spinal'. There are unanswered questions about potential prolonged effects of either general anaesthesia or nerve block or both in delaying re-mobilisation and re-enablement in the early postoperative period, which have been linked to poorer outcomes previously [20]. Conversely, nerve blocks have a potentially beneficial role in reducing opioid analgesia requirements [21]. The recently completed femoral nerve block intervention in neck of femur fracture (FINOF) study may provide more clarity about the role of nerve blocks [22]. It was not surprising that type of anaesthesia was not found to be significantly associated with postoperative length of stay, given that this is more likely to be affected by organisational than clinical issues [21].

While we were encouraged that consultant or specialist anaesthetists and surgeons were present during a high proportion of operations (~92% [9]), we were not surprised to find that outcomes were similar when other grades delivered anaesthesia and surgery. Anecdotally, trainees have become increasingly well trained in delivering care for hip fracture patients. Conversely, many patients are still cared for by consultants/specialists who only occasionally undertake trauma lists. In hindsight, it may have been better to analyse the grade of clinician and their level of expertise in caring for hip fracture patients, and we would encourage future research in this area.

We think that the most important findings of ASAPs-1 and -2 concern intra-operative hypotension. However defined [23], more than half of the patients in ASAP-1 had significant hypotension, more often during general anaesthesia than spinal anaesthesia. Associations between higher postoperative 30-day mortality [24] and morbidity [25] with lower intra-operative mean arterial blood pressures have been reported after non-cardiac surgery. It is plausible that mean arterial hypotension leads to critical organ hypoperfusion and ischaemic postoperative complications, including delirium [26–28], dysrhythmia and acute kidney injury [29], which are independently associated with poorer outcomes.

The association of lower doses of spinal anaesthetic with higher intra-operative blood pressures in ASAP-2 is consistent with previous work [30]. The association was relatively weak, largely due to substantial variation in blood pressure changes at any given dose. In addition, interventions such as fluid administration and/or use of vasopressors, may have countered a direct causal effect by limiting reductions in blood pressure. Lower doses of bupivacaine were associated with reduced variability in the range of relative changes in systolic blood pressure; this requires further investigation, given that blood pressure variation is associated with postoperative delirium in older patients undergoing major non-cardiac surgery [31]. Our data support anaesthetists reducing the intrathecal dose of bupivacaine towards 1.5 ml.

In conclusion, these prospective data support previous observational work that the type of anaesthetic technique is not associated with patient outcome. We invite interested readers to analyse these audit data further through correspondence submitted to the journal. In the near future, we aim to collate an open-access, online library of research questions that remain outstanding and how these might best be addressed. However, this may be of lesser importance in the long term than singularly addressing the biggest potential challenge to improving the peri-operative care of hip fracture patients, namely reducing the observed variation in outcomes between practitioners and hospitals by introducing standardised national quality improvement protocols based on best practice evidence.

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ber of the Age Anaesthesia Association whom he represents at the National Hip Fracture Database, is national research co-ordinator for the Hip Fracture Peri-operative Network, sits on the Scientific and Publications Committee of the National Hip Fracture Database and the NIAA Grants Committee, and is an Editor of *Anaesthesia*. This manuscript has therefore undergone additional external review. RG chaired the AAGBI Hip Fracture Guidelines Working Party and founded the Hip Fracture Peri-operative Network. He is also Honorary Secretary of the AAGBI. IM is a member of the NICE topic expert group for Quality Standards for hip fracture, a member of the National Institute of Academic Anaesthesia (NIAA) Research Council and holds grants from the National Institute for Health Research and the AAGBI and Royal College of Anaesthetists through the NIAA for trials in hip fracture. MG serves on the NIAA Board and Research Council and on the editorial board of *Perioperative Medicine*.

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