Randomized controlled trial to investigate influence of the fluid challenge on duration of hospital stay and perioperative morbidity in patients with hip fractures[†]

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Background. A prospective, randomized controlled trial comparing conventional intraoperative fluid management with two differing methods of invasive haemodynamic monitoring to optimize intraoperative fluid therapy, in patients undergoing proximal femoral fracture repair under general anaesthesia.

Methods. Ninety patients randomized to three groups; conventional intraoperative fluid management (Gp CON, *n*=29), and two groups receiving additional repeated colloid fluid challenges guided by central venous pressure (Gp CVP, *n*=31) or oesophageal Doppler ultrasonography (Gp DOP, *n*=30). Primary outcome measures were time to medical fitness to discharge, hospital stay and postoperative morbidity.

Results. The fluid challenge resulted in significantly greater perioperative changes in central venous pressure between Gp CVP and Gp CON (mean 5 (95% confidence interval 3–7) mm Hg) ($P<0.0001$). Important perioperative changes were also shown in Gp DOP with increases of 49.4 ms (19.7–79.1 ms) in the corrected flow time, 13.5 ml (7.4–19.6 ml) in stroke volume, and 0.9 (0.49–1.39) litre min^{-1} in cardiac output. As a result, fewer patients in Gp CVP and Gp DOP experienced severe intraoperative hypotension (Gp CON 28% (8/29), Gp CVP 9% (3/31), Gp DOP 7% (2/30), $P=0.048$ (chi-squared, 2 degrees of freedom (df)). No differences were seen between the three groups when major morbidity and mortality were combined, $P=0.24$ (chi-squared, 2 df). Postoperative recovery for survivors, as defined by time to be deemed medically fit for discharge, was significantly faster, in comparison with Gp CON, in both the Gp CVP (10 *vs* 14 (95% confidence interval 8–12 *vs* 12–17) days, $P=0.008$ (*t*-test)), and Gp DOP (8 *vs* 14 (95% confidence interval 6–12 *vs* 12–17) days, $P=0.023$ (*t*-test). There were no significant differences between groups, for survivors, with respect to acute orthopaedic hospital and total hospital stay.

Conclusions. Invasive intraoperative haemodynamic monitoring with fluid challenges during repair of femoral fracture under general anaesthetic shortens time to being medically fit for discharge.

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Hip fracture patients are an elderly hospital population who are at high risk of postoperative complications and mortality, and consequently represent an important resource allocation. They occupy 20% of orthopaedic beds, for an average of 25.1 days, with a variable 90-day mortality of between 5 and 24%,[1 2] and less than a quarter of survivors return to their pre-fracture activities of daily living at 90 days.[1 2] In our hospital, patients at high risk of postoperative morbidity and mortality presenting for major surgery, are admitted to the intensive care/high dependency unit for optimization of cardiac output and tissue oxygen delivery, with the aid of a pulmonary artery catheter, as suggested by Boyd and colleagues.[3] This has resulted in a 75% reduction in mortality and 50% reduction in major morbidity, and these improvements have been sustained in our hospital.[4] Unfortunately, the National Health Service does not have the resources at present to admit all patients presenting with hip fracture to a critical care area as has been suggested,[5] and pulmonary artery catheterization is not easily performed outside the theatre or critical care setting.

An alternative solution was, therefore, needed to optimally manage this high-risk hip fracture population, since an audit of 94 consecutive hip fractures in our hospital had shown that increased intraoperative fluid administration was associated with decreased morbidity and mortality. Sinclair and colleagues[6] showed that intraoperative volume optimization guided by oesophageal Doppler ultrasonography led to reductions in postoperative recovery and hospital stay in patients with fractured hips. Doppler ultrasonography is not easily available in all hospitals and requires a degree of operator skill with the patient deeply sedated or anaesthetized to tolerate the insertion of the ultrasound probe into the oesophagus. Central venous pressure measurement is, however, routinely used for haemodynamic monitoring and treatment during major operations, and has the advantage that it is well tolerated by an awake patient. Consequently we investigated whether repeated colloid fluid challenges to optimize the circulation intraoperatively, guided by central venous pressure or oesophageal Doppler ultrasonography, would benefit high-risk patients admitted with fractured hips to a London teaching hospital.

Methods

Following approval of the Local Research Ethics Committee (LREC 98.15.18), all patients admitted with fractured hips were considered for inclusion into this study. Informed written consent was sought from all patients, but was not possible for 35 patients because of diminished mental capacity. Patients who were unable to give informed consent themselves were not excluded, but the next of kin was informed where possible, in accordance with the LREC guidelines. Exclusion criteria were patients aged less than 65 yrs, oesophageal pathology, patients with a central venous cannula already *in situ*, pathological fracture of femur, refusal of informed consent, and patients undergoing regional anaesthesia.

Preoperatively patients received any necessary medical interventions felt appropriate by the admitting orthopaedic surgeons, and all patients received regular oral paracetamol and dihydrocodeine, and i.m. morphine as required for analgesia. Maintenance i.v. fluid (1000 ml crystalloid 12 hourly) was commenced from the time that the patient was scheduled to undergo surgery and continued up to the time of operation. Mobility before fracture and mental test score[7] were recorded. Severity of illness was recorded using the American Society of Anesthesiologists' grading of Health Status,[8] and by calculation of the physiology and operative severity score for the enumeration of mortality and morbidity (POSSUM) for the orthopaedic population.[9]

The conduct of general anaesthesia performed for all patients was standardized and managed by an independent clinician. The investigator team initiated the additional fluid-directed therapy. Induction of anaesthesia consisted of propofol and fentanyl, intubation was facilitated by vecuronium, and anaesthesia was maintained with oxygen, nitrous oxide, and isoflurane. No specific premedication was used although some patients received i.m. opiates before surgery for analgesia. Perioperative analgesia was provided for by a combination of fentanyl, nitrous oxide and a '3 in 1' inguinal perivascular nerve block.[10] Where peripheral nerve block was not possible or considered contraindicated, i.v. morphine was administered to provide immediate postoperative analgesia. Essential monitoring of the cardiovascular and respiratory systems was commenced before induction and continued into the recovery period as per routine practice.

In addition, patients were individually randomized into three groups, through the use of a set of computer-generated random numbers and an opaque sealed envelope technique, to receive further minimally invasive haemodynamic monitoring. The control group (Gp CON) and central venous pressure-directed therapy group (Gp CVP) received a catheter inserted into a central vein (Angiocath 16 G, Becton Dickinson, UT, USA), or Drum-cartridge catheter 16 G (Abbott, Ireland) for the basilic/cephalic vein approach. The Doppler-directed therapy group (Gp DOP) received a 6-mm diameter oesophageal Doppler (OD) ultrasound probe (Deltex Medical Ltd, Chichester, UK) inserted through the mouth into the oesophagus, after induction of anaesthesia. The central venous catheter was connected to a pressure transducer, and the pressure trace displayed continuously and recorded every 10 min. The OD probe was connected to the ultrasound source and detector and continuously monitored. After positioning in the oesophagus as previously described,[6] the OD probe measured and displayed cardiac output, stroke volume, and corrected aortic systolic flow time continuously and these results were recorded every 10 min.

Intraoperatively, all patients received i.v. crystalloid (Hartmann's solution), colloid in the form of gelofusine,

Time	CVP (mm Hg)	Gelofusine fluid challenge
Initial reading	<14	200 ml
	≥14	100 ml
During fluid challenge	Increase >5	Stop fluid challenge and WAIT
Following fluid challenge	Increase >3	WAIT
	≤3	Repeat fluid challenge as per initial reading

Fig 1 Procedure to guide gelofusine fluid challenges according to dynamic changes in central venous pressure, for CVP-directed therapy group (Gp CVP).

or blood to replace estimated and measured fluid losses, in an attempt to maintain heart rate and arterial pressure within 20% of pre-induction baseline levels. In Gp CON, clinicians were able to give i.v. fluid as they thought appropriate. Although central venous pressure was monitored and recorded by the investigator, the clinician was unaware of these measurements and so was unable to use them to guide therapy. The investigator gave no additional fluids in this group. In Gp CVP, patients received additional 200 ml gelofusine fluid challenges guided by the response of the central venous pressure to a fluid challenge from the investigator, in addition to any fluid given by the clinician. This procedure was formulated by modifying guidelines produced by Weil and colleagues,[11] and is shown in Figure 1. In Gp DOP, patients received additional 200 ml gelofusine fluid challenges guided by Doppler measurements of stroke volume and corrected flow time from the investigator, in addition to any fluid given by the clinician. This procedure was similar to that performed by Sinclair and colleagues,[6] with the exception that if the corrected flow time rose above 0.4 s and the stroke volume remained the same, a further 100 ml gelofusine fluid challenge was given. If after this fluid challenge the stroke volume still remained the same then no further fluid was given until the stroke volume fell by 10%. The rationale for this minor change was based on observations in similar age group patients before the study, where the initial corrected flow time was frequently greater than 0.4 s although these patients were obviously clinically hypovolaemic and responded appropriately to a fluid challenge.

Operation time was recorded as being the time from when the patient entered the operating theatre to the time of skin closure. The 'initial' and 'final' recordings of central venous pressure or oesophageal Doppler ultrasonography measurements were at the start and end of the operating time. The anaesthetist was unaware of the central venous pressure or oesophageal Doppler ultrasonography measurements, by the use of stand-alone monitors, which were screened from the anaesthetist. The anaesthetist was, however, informed of all fluid volumes given in the procedure groups (Gp CVP and Gp DOP). At the end of the operation, the central venous cannula or OD probe was removed from the patient. Severe intraoperative hypotension was defined as greater than 50% reduction in systolic arterial pressure requiring rapid fluid infusion by the anaesthetist and/or vasoconstrictor therapy.

Postoperative management was performed by the orthopaedic medical team and nursing staff who were all unaware of the patient's randomization. Major postoperative morbidity for survivors was recorded as used in the data collection for the POSSUM scoring system.[9] The dates of discharge or transfer from the orthopaedic ward were recorded to determine duration of acute orthopaedic hospital stay and total hospital stay, which included acute orthopaedic and geriatric care, for survivors. However, it is well recognized that in elderly orthopaedic patients the duration of hospital stay is often related to social circumstances and not to clinical health.[12] Consequently, the time when these patients were deemed medically fit by the orthopaedic team to return to their previous abode was also documented.

Statistical analysis

Primary outcome measures were time to medical fitness to discharge, hospital stay, and postoperative morbidity in survivors. Secondary outcome measures were differences in intraoperative central venous pressure measurements between Gp CON and Gp CVP, and severe intraoperative hypotension between all three groups.

From previous studies and our own audit, the sample size (30 in each group) was determined to show a one-fifth reduction in time to medical fitness to discharge,[6] and hospital stay,[6] and a 50% reduction in the total number of postoperative complications for survivors in Gp CVP and Gp DOP[3 13] (α value of 0.05, and a β value of 0.8). The control group (Gp CON) stay was based on our previous audit and was comparable with that of Sinclair and colleagues.[6] ANOVA and the *t*-test were used for continuous data. The chi-squared test with 2 degrees of freedom (df) was used to compare categorical variables between the three groups. For comparing number of days to discharge, the reciprocal value was used in order to normalize the distribution. Confidence intervals are shown after back transforming. Mean and 95% confidence intervals are quoted unless otherwise stated. *P* value <0.05 was considered significant.

All analysis was carried out using Statview for Windows software package (version 4.57; Abacus Concepts Inc., Berkeley, CA, USA).

Results

One hundred and fourteen patients were visited preoperatively of whom 90 met the entry criteria. Randomization resulted in 29 patients allocated to Gp CON, 31 to Gp CVP, and 30 to Gp DOP. The operation was changed for one

Table 1 Physical characteristics of patients, preoperative and operative characteristics in the control group (Gp CON), CVP-directed therapy group (Gp CVP), and Doppler-directed therapy group (Gp DOP). Values are mean (SD), median (interquartile range), or numbers of patients. Significantly greater number of DHS procedures performed in Gp CVP compared with Gp CON (P=0.04) and Gp DOP (P=0.05)

	Gp CON	Gp CVP	Gp DOP
Number allocated	29	31	30
Age (yr) [range]	84.5 (9.3) [65–102]	85.0 (6.2) [74–98]	82.0 (8.7) [65–97]
Sex (M:F)	6:23	4:27	6:24
American Society of Anesthesiologists' grading	3 (3–4)	3 (3–4)	3 (2.5–3)
POSSUM (orthopaedic)	38 (34–40)	40 (35–42)	35 (32–40)
Predicted mortality from POSSUM (%)	15.3 (9.4–19)	19 (10.9–26.3)	11.6 (7.7–19)
Mental test score	10 (5–10)	8 (3.5–10)	7.5 (2–10)
Mobility before fracture			
Fully mobile	18	13	20
Requires aid (e.g. stick) or transfers only	11	18	10
Operative delay (days)	2 (1–2)	2 (1–2)	2 (1–2.5)
Preoperative intravenous fluids (litres 24 h^{-1})	2 (1–2)	1.5 (1–2)	1.25 (0.5–2)
Operation			
Dynamic hip screw	11	21	13
Arthroplasty	17	9	14
AO screw	1	0	3
Operative time (min)	70 (55–80)	70 (42.5–80)	57.5 (47.5–65)
'3 in 1' nerve block	16	20	20

Table 2 Intraoperative fluids and blood loss in the control group (Gp CON), CVP-directed therapy group (Gp CVP), and Doppler-directed therapy group (Gp DOP). Values are means (95% confidence intervals)

	Group A (control)	Group B (CVP)	Group C (Doppler)	ANOVA P value
Intraoperative crystalloid (ml)	1286 (1100–1473)	1156 (998–1315)	1120 (983–1257)	0.31
Intraoperative colloid (ml)	448 (319–576)	1123 (921–1324)	1207 (1077–1336)	<0.0001
Intraoperative blood loss (ml)	341 (263–420)	429 (299–560)	275 (215–336)	0.07
Total intraoperative fluids minus blood loss (ml)	1392 (1170–1615)	1850 (1654–2045)	2051 (1854–2249)	<0.0001

patient in Gp CVP, following randomization, to intramedullary femoral nailing, but data are included on an intent to treat basis. The physical characterization of patient's severity of illness, preoperative mobility, mental test score, preoperative delay to operation, preoperative fluids, operative time, and number of patients receiving a nerve block were similar in the three groups (Table 1). Patients underwent significantly more dynamic hip screw procedures in Gp CVP compared with Gp CON (P=0.04) and Gp DOP (P=0.05).

There were no complications related to oesophageal Doppler ultrasonography, but central venous cannula insertion resulted in one pneumothorax (resolved spontaneously with no intervention) and four carotid artery punctures (resulted in minor bruising only).

Patients in the two procedure groups (Gp CVP and Gp DOP) had a significantly greater positive fluid balance intraoperatively (457 (137–777) and 659 (336–982) ml, respectively) than Gp CON, P<0.0001 (ANOVA) (Table 2). Perioperative changes seen in Gp DOP were increased corrected flow time 49.4 ms (19.7–79.1 ms), increased stroke volume 13.5 ml (7.4–19.6 ml), and increased cardiac output 0.9 litre min^{-1} (0.49–1.39 litre min^{-1}). There was a significantly greater increase in central venous pressure in Gp CVP compared with Gp CON (mean 5 (95% confidence interval 3–7) mm Hg) (P<0.0001) (Fig. 2).

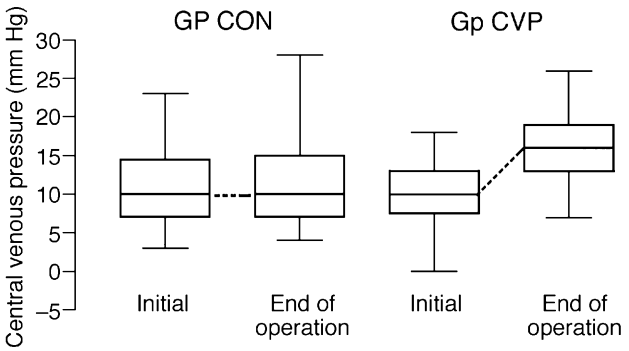

Fig 2 Changes in intraoperative central venous pressure measurements between the control group (Gp CON) and CVP-directed therapy group (Gp CVP). (Median, interquartile range and extremes shown).

Severe intraoperative hypotension was recorded in eight, three, and two patients in Gp CON, Gp CVP, and Gp DOP respectively, P=0.048 (chi-squared, 2 df). This reduction in patients with intraoperative hypotension was not statistically significant between Gp CVP and Gp CON (P=0.07), in contrast to Gp DOP *vs* Gp CON (P=0.03). Postoperative morbidity for survivors in Gp CVP and Gp DOP was seen in 8/31 (26%) and 7/30 (23%) patients, respectively, compared with 14/29 (49%) patients in the control group, P=0.078 (Table 3). Overall predicted morbidity from POSSUM was

59%. There were a total of 11 hospital deaths during the course of the study, two in Gp CON, six in Gp CVP, and three in Gp DOP (P=0.31). No differences were seen between the three groups when major morbidity and mortality were combined, P=0.24. Overall predicted mortality from POSSUM was 18%, and actual mortality 12%. The median POSSUM scores for those who died were high (47.5) predicting a high mortality in this group (predicted POSSUM mortality=72%).

There was a statistically significant reduction in the number of days to being declared medically fit for discharge, for survivors, between the three groups, Gp CON 14 (12–17) days, Gp CVP 10 (8–12) days and Gp DOP 8 (6–12) days, P=0.035 (ANOVA) (Table 4). This reduction in days was significant when comparing both the Gp CVP and Gp CON (10 *vs* 14 (95% confidence interval 8–12 vs 12–17), respectively) days, P=0.008 (t-test)), and Gp DOP and Gp CON (8 *vs* 14 (95% confidence interval 6–12 *vs* 12–17), respectively) days, P=0.023 (t-test). There were no significant differences between the three groups, for survivors, with respect to acute orthopaedic hospital stay and total hospital stay, P=0.20 and 0.30, respectively (ANOVA). Total number of hospital days (survivors and non-survivors) between the three groups are shown in Figure 3.

Table 3 Episodes of postoperative morbidity (in survivors) in the control group (Gp CON), CVP-directed therapy group (Gp CVP), and Doppler-directed therapy group (Gp DOP). Total episodes of morbidity in survivors shown, followed by total episodes of morbidity and mortality in all patients. *Postoperative day 8

Description of postoperative morbidity[9]	Numbers of patients		
	Gp CON	Gp CVP	Gp DOP
Deep haemorrhage requiring >2 unit blood transfusion	1	0	1
Haematemesis	1	0	0
Chest infection	5	3	2
Wound infection	2	0	0
Urinary tract infection	3	1	2
Cellulitis	0	1	0
Pancreatitis	1	0	0
Pulmonary embolus	0	0	1
Cerebrovascular accident	1	1	2
Myocardial infarction	0	1	0
Cardiac failure	0	1*	0
Rapid atrial fibrillation	2	1	3
Hypotension	3	0	0
Impaired renal function	2	0	0
Pseudo-obstruction	0	1	0
Total morbidity in survivors	*21*	*10*	*11*
Mortality	2	6	3
Total morbidity and mortality	*23*	*16*	*14*

Discussion

Patients presenting to our hospital with hip fractures are an elderly population (median age 85 yrs), who are at high risk of perioperative morbidity and mortality as illustrated by their POSSUM scores. They are frequently hypovolaemic on admission to hospital for a variety of factors including concomitant therapies (e.g. diuretics), inadequate fluid intake because of immobility following fracture and/or dementia, and reluctance to drink because of anxiety over incontinence. This will exacerbate any tissue hypoperfusion arising as a result of surgery with potential organ dysfunction in the perioperative period. This may be reflected clinically in increased postoperative morbidity, duration of hospital stay and mortality. Perioperative optimization of the circulatory volume aims to maximize cardiac performance and thus minimize this tissue oxygen debt in the perioperative period.[3 6 14 15] The significantly increased intraoperative fluid administration in the two procedure-driven groups (Gp CVP and Gp DOP) in this study was a consequence of this concept, and translated into clinical benefits. We showed a reduction in the frequency of intraoperative hypotension, a trend towards reduced postoperative morbidity in survivors and a faster postoperative recovery, gauged by the reduction in the number of days before being declared medically fit for discharge from hospital compared with the control group. There is frequent anxiety amongst clinicians in the perioperative period that these elderly groups of patients with comorbidities are at danger of i.v. fluid overload, which may potentially lead to cardiac failure, and thus there is a reluctance to prescribe sufficient i.v. fluids. In this study we have clearly shown that the majority of patients in fact have occult hypovolaemia, and tolerate increased i.v. fluid therapy to their benefit.

It is well recognized that routine perioperative haemodynamic monitoring (heart rate and arterial pressure) is insensitive to occult hypovolaemia,[14] and is only able to detect major circulatory losses. Consequently, invasive methods of monitoring the circulation will be required if occult hypovolaemia is to be adequately treated and inadvertent fluid overload avoided. The wide range of additional colloid required in our procedure groups (Gp CVP and Gp DOP) emphasizes the fact that giving a single volume load is not appropriate when applied to individuals. Fluid must be individually titrated to dynamic changes in

Table 4 Days before declared medically fit for discharge, acute orthopaedic and total (orthopaedic and geriatric) hospital stays for survivors, in the control group (Gp CON), CVP-directed therapy group (Gp CVP), and Doppler-directed therapy group (Gp DOP). Values are means (95% confidence intervals)

	Gp CON	Gp CVP	Gp DOP	ANOVA P value
Days before declared medically fit for discharge	13.9 (11.9–16.9)	10.0 (8.1–12.0)	7.7 (5.9–12.3)	0.035
Acute orthopaedic hospital stay (days)	16.7 (13.2–22.2)	11.1 (8.3–17.5)	12.5 (11.1–16.7)	0.17
Total (orthopaedic and geriatric) hospital stay (days)	17.5 (13.9–24.4)	13.3 (10.3–19.2)	13.5 (10.9–17.5)	0.27

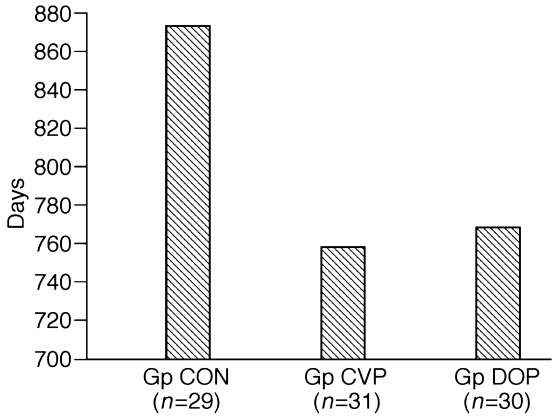

Fig 3 Total number of days spent in hospital (orthopaedic and geriatric), for all study patients (survivors and non-survivors), between the control group (Gp CON), CVP-directed therapy group (Gp CVP), and Doppler-directed therapy group (Gp DOP).

appropriate monitoring. The effectiveness of oesophageal Doppler ultrasonography has already been proven in this context,[6] and our study confirms this. Unfortunately, the present lack of familiarity and availability of this monitor, combined with the necessity for a sedated patient for insertion and manipulation of the OD probe, have so far prevented its widespread introduction for perioperative use. We have shown that monitoring the dynamic changes of central venous pressure in response to a fluid challenge produces equivalent benefits. The advantage of both techniques is that they do not require a critical care bed.

Several factors are known to influence outcome in this particular population of patients including dementia, reduced pre-fracture mobility and operative delay.[16–18] There were no differences in these three factors between the groups studied. General anaesthesia has no adverse effect on outcome for fracture hip repair although one study showed reduced early mortality for subarachnoid anaesthesia.[19] However, there were no differences in mortality rates at 2 months and both the Cochrane review[20] and The Baltimore Hip Studies group[21] have failed to show any benefit from subarachnoid anaesthesia. The early reduction in mortality with subarachnoid anaesthesia may simply be a reflection of increased fluid loading given to counteract the sympathetic block, which coupled with the consequent vasodilatation will reduce tissue hypoperfusion and protect against thromboembolism. Although a significantly greater number of DHS procedures occurred in Gp CVP, no differences in morbidity and mortality have previously been shown between DHS and hemiarthroplasty.[22]

There was no statistical difference in mortality between the groups and the study was purposefully not powered to show any difference in mortality. This would have required over 300 patients. It was felt unlikely that we would improve medium and long-term mortality, which are determined by the co-morbidities frequently precipitating the fall and subsequent fracture, such as dementia and reduced mobility as a result of a variety of pathologies.

We were unable to show an actual reduction in acute orthopaedic or total hospital stay. Duration of hospital stay is often a poor indicator of outcome because it depends on too many variables.[12] In the elderly hip fracture population, this is even more evident as arrangements for assessments of daily living activity and institution of subsequent recommendations varying from home adaptions to organization of nursing home care, take time to organize, and are usually a scarce resource. Consequently, our collection of the data recording duration to being declared medically fit for discharge is more meaningful as a medical outcome measure. That the patient subsequently stayed in hospital longer than this period is an indication of the complexity of arranging discharge from hospital for these elderly patients. Sinclair and colleagues,[6] showed reductions in hospital stay in addition to medical fitness to discharge and this may have been a reflection of their younger and fitter population. It is unlikely that a single intraoperative intervention will ever show the economic benefit of a reduction in hospital stay in our hip fracture population, because of the complexity of discharge for these patients. However if included in a package of care which addresses all those other factors which are known to affect outcome in the hip fracture population,[16] then this intervention may impact on hospital stay with subsequent socio-economic benefits.

References

1 Todd CJ, Freeman CJ, Camilleri-Ferrante C, *et al.* Differences in mortality after fracture of hip: the east Anglian audit. *BMJ* 1995; **310**: 904–8

2 Laxton C, Freeman C, Todd C, *et al.* Morbidity at 3 months after hip fracture: data from the East Anglian audit. *Health Trends* 1997; **29**: 55–60

3 Boyd O, Grounds RM, Bennett ED. A randomized clinical trial of the effect of deliberate perioperative increase of oxygen delivery on mortality in high-risk surgical patients. *JAMA* 1993; **270**: 2699–707

4 Curran JE, Grounds RM. Ward versus intensive care management of high-risk surgical patients. *Br J Surg* 1998; **85**: 956–61

5 Sharrock NE. Fractured femur in the elderly: intensive perioperative care is warranted. *Br J Anaesth* 2000; **84**: 139–40

6 Sinclair S, James S, Singer M. Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial. *BMJ* 1997; **315**: 909–12

7 Hodkinson HM. Evaluation of a mental test score for assessment of mental impairment in the elderly. *Age Ageing* 1972; **1**: 233–38

8 American Society of Anesthesiologists. New classification of physical status. *Anesthesiology* 1963; **24**: 111

9 Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. *Br J Surg* 1991; **78**: 355–60

10 Lee A, Wildsmith JAW. Local anaesthetic techniques. In: Aitkenhead AR, Smith G, *Textbook of Anaesthesia*, 2nd Edn. Edinburgh: Churchill Livingstone, 1990: 482

11 Weil MH, Henning RJ. New concepts in the diagnosis and fluid treatment of circulatory shock. *Anesth Analg* 1979; **58**: 124–32

12 Chumbley GM, Hall GM. Recovery after major surgery: does the anaesthetic make any difference. *Br J Anaesth* 1997; **78**: 347–48

13 Berlauk JF, Abrams JH, Gilmour IJ, Rhiannon O'Connor S, Knighton DR, Cerra FB. Preoperative optimisation of cardiovascular hemodynamics improves outcome in peripheral vascular surgery. *Ann Surg* 1991; **214**: 289–98

14 Shoemaker WC, Appel PL, Kram HB, Waxman K, Lee T-S. Prospective trial of supranormal values of survivors as therapeutic goals in high-risk surgical patients. *Chest* 1988; **94**: 1176–186

15 Wilson J, Woods I, Fawcett J, *et al*. Reducing the risk of major elective surgery: randomised controlled trial of preoperative optimisation of oxygen delivery. *BMJ* 1999; **318**: 1099–103

16 March LM, Chamberlain AC, Cameron ID, *et al*. How best to fix a broken hip. Fractured neck of femur health outcomes project team. *Med J Aust* 1999; **170**: 489–94

17 Elliot JR, Wilkinson TJ, Hanger HC, *et al*. The added effectiveness of early geriatrician involvement on acute orthopaedic wards to orthogeriatric rehabilitation. *N Z Med J* 1996; **109**: 72–3

18 vanDortmont LM, Oner FC, Wereldsma JC, Mulder PG. Effect of mental state on mortality after hemiarthroplasty for fracture of the femoral neck. A retrospective study of 543 patients. *Eur J Surg* 1994; **160**: 203–8

19 McKenzie PJ, Wishart HY, Smith G. Long-term outcome after repair of fractured neck of femur. Comparison of subarachnoid and general anaesthesia. *Br J Anaesth* 1984; **56**: 581–5

20 Parker MJ, Urwin SC, Handoll HHG, Griffiths R. General versus spinal/epidural anaesthesia for surgery for hip fractures in adults. In: Cochrane Collaboration. *The Cochrane Library*. Oxford: Update Software, Issue 4, 1999

21 Gilbert TB, Hawkes WG, Hebel JR, *et al*. Spinal anesthesia versus general anesthesia for hip fracture repair: a longitudinal observation of 741 elderly patients during 2-year follow-up. *Am J Orthop* 2000; **29**: 25–35

22 Ravikumar KJ, Marsh G. Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur—13 year results of a prospective randomised study. *Int J Care Injured* 2000; **30**: 793–7