# An observational study of cardiac output changes during regional anaesthesia in patients with fractured neck of femur.

J Brombacher, I Hodzovic, S Ridgway, T Mian, J Mecklenburgh

**Citation**

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**Abstract**

Background and objectives: Regional anaesthesia is a popular choice for repair of fractured neck of femur. We found very few studies looking at the cardiac output changes during regional anaesthesia for this procedure. We therefore decided to observe cardiac output changes in patients undergoing repair of fractured neck of femur under regional anaesthesia using Lithium Dilution Cardiac Output Monitor.Methods: Twenty one fractured neck of femur patients agreed to take part in this observational study. Cardiac output, stroke volume, invasive blood pressure and heart rate data were recorded from the time before the establishment of regional anaesthesia until completion of surgery. Results:The cardiac output changes occurred mostly within the first 25 min after intrathecal administration of local anaesthetic. Stroke volume and cardiac output decreased on average by 15% and 20% respectively. We recorded an average reduction of 22% in systemic vascular resistance and of 20% in mean arterial pressure from pre-anaesthetic levels.Conclusions:Regional anaesthesia for fractured neck of femur repair can be associated with significant changes in cardiac output. Most prominent changes happened within the first 25 minutes after intrathecal injection. Vasoconstrictors and fluid appear to be appropriate first line treatment. Minimally invasive cardiac output monitoring is likely to be beneficial in this high risk population of surgical patients.

## INTRODUCTION

Regional anaesthesia is frequently the anaesthetic technique of choice for repair of fractured neck of femur [1,2,3]. Patients admitted for surgery to a fractured neck of femur are elderly with significant cardiac co-morbidities [4] and are frequently dehydrated on admission [1]. Trauma and surgery induce the stress response and increase the strain upon an already compromised cardiovascular system [1]. Recent National Confidential Enquiry into Peri-Operative Deaths (NCEPOD) report have highlighted the deleterious effects of both over and under hydration in the elderly [5]. Sinclair et al [6] and Venn et al [7] have shown that close monitoring and optimisation of cardiac output with fluid boluses in this group of patients speeds the postoperative recovery and reduces the time to discharge. Both of these studies were done in patients who received general anaesthesia for the repair of fractured neck of femur, using oesophageal Doppler for cardiac output measurement. A number of studies looked at cardiac output changes during regional anaesthesia using thoracic impedance cardiac output monitor [8,9,10,11,12]. We could find only one study that used Lithium dilution cardiac output monitor to look at the changes in cardiac output during regional anaesthesia [13]. Concerns about morbidity and mortality with pulmonary artery catheterisation [14] have inspired a search for less invasive forms of cardiac output measurement. Most of the currently available minimally invasive methods of cardiac output measurements either require patients to be anaesthetised (Non-Invasive Cardiac Output, NICO monitor, Oesophageal Doppler) or require cannulation of the large central blood vessels (pulse contour cardiac output, PiCCO monitor). Recently introduced Oesophageal Doppler for use in awake patients was not available at the time of our study.

Lithium Dilution Cardiac Output (LiDCO) (LiDCO™, London, UK) monitor is a minimally invasive method for measuring cardiac output. This device combines an indicator dilution technique (using Lithium as an indicator) with arterial waveform programme (Pulse Contour analysis). It comprises of a lithium sensitive electrode attached to a peripheral catheter. The former measures the lithium ion concentration, which is given as a bolus of lithium chloride via a peripheral intravenous cannula. The lithium dilution method has been shown 'to be at least as accurate as bolus thermodilution' via pulmonary artery catheter [15]. For patients not on lithium therapy, the bolus dose of lithium chloride, applied for cardiac output assessment is too small to have a pharmacological effect [16]. The LiDCO monitor gives beat-to-beat stroke volume and cardiac output measurements as well as variations in systolic, pulse pressure and stroke volume figures which can be used as a guide to fluid administration during surgery. All that is required in addition to the peripheral venous access is an arterial line [15].

We therefore decided to look at the cardiac output changes during regional anaesthesia in patients undergoing surgery for the repair of fractured neck of femur using LiDCO cardiac output monitor.

## METHODS

An observational non-interventional study design was used. Following approval of the Local Research Ethics Committee we considered all patients admitted for urgent repair of fractured neck of femur at the Royal Gwent Hospital in South Wales, United Kingdom (UK). They were offered the opportunity to take part in the study. A written informed consent was obtained from 21 patients. We excluded patients with diminished mental capacity, patients who refused to take part, patients on lithium therapy and patients who in the opinion of the anaesthetist in charge of the patient (not a member of the research team) required general anaesthesia. Inclusion criteria were ASA grade I, II or III patients that were undergoing repair of fractured neck of femur under regional anaesthesia.

Premedication was given as deemed necessary by the anaesthetist responsible for the care of the patient. In addition to routine monitoring the LiDCO cardiac output monitor was used. After initial arterial and venous line cannulation, the LiDCO monitor was calibrated by intravenous administration of lithium chloride. Cardiac output, stroke volume, invasive blood pressure and heart rate data were recorded from the time before administration of regional anaesthesia until the end of surgery. The anaesthetist in charge of the case was blinded to the reading of LiDCO monitor. Prior to positioning the patient received a sedation and/or analgesic cover according to the standard practice of the anaesthetist in charge. Regional anaesthesia was established with the patient in the lateral position. The volume and type of local anaesthetic as well as administration of fluids and vasoactive drugs were responsibility of the anaesthetist in charge. In addition, the interventions were marked as events on the monitor and were downloaded together with the cardiovascular recordings onto a laptop at the end of the procedure.

## RESULTS

Patient and regional anaesthesia related values are summarised in Table 1. Five patients received

isobaric 0.5% bupivacaine and 16 patients received hyperbaric 0.5% bupivacaine. In nine patients fentanyl was added to the local anaesthetic. One patient received 2 injections (2.7 ml and 2.2 ml of 0.5% hyperbaric bupivacaine) resulting in a sensory block to L2 measured to cold after the first injection which increased to T10 after the second one. Another patient received 2 injections (2 ml of 0.5% hyperbaric and 2.2 ml of isobaric 0.5% bupivacaine) both of which failed to produce a sufficient sensory block. Repeated ketamine boluses were administered in this patient to provide anaesthesia.

### Figure 1

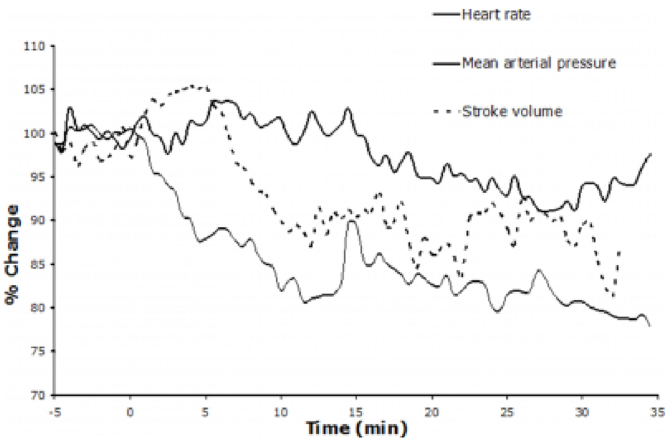
Table 1: Patient related values expressed as mean (range), median (range) and number as appropriate. *From the time of the spinal injection until completion of skin closure.

| | |
|---|---|
| Age (years) | 83 (57-94) |
| Weight (kg) | 69 (40 - 95) |
| ASA II / III | 9 / 12 |
| Bupivacaine 0.5% (ml) | 2.5 (1.2 - 4.9) |
| Upper level of sensory block (to cold) | T8 (T11-T5) |
| Duration of surgery (min)* | 83.7 (54 - 123) |

Changes in the heart rate, stroke volume and mean arterial pressure after spinal injection of local anaesthetic are presented in Figure 1. Mean arterial pressure fell to 80% of the baseline with lowest values at 20 min post intrathecal injection. This was caused by an early decrease in systemic vascular resistance followed by stroke volume and cardiac output reduction of similar magnitude. The heart rate did not change significantly throughout (Figures 1 and 2). Majority of observed changes (94%) happened within 25 min of the local anaesthetic administration. The average time for stroke volume to reach lowest value was 22 min, for cardiac output and for mean arterial pressure 25 min and systemic vascular resistance dropped to its lowest value 12 min after intrathecal administration of local anaesthetic.

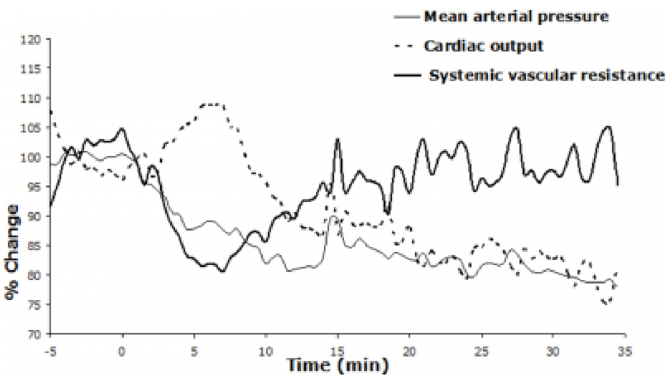
### Figure 2

Figure 1: Mean changes in heart rate, mean arterial pressure and stroke volumes after spinal injection (time 0) in 21 patients.




### Figure 3

Figure 2: Mean changes in mean arterial pressure, cardiac output and calculated systemic vascular resistance after spinal injection (time 0) in 21 patients.




The volume and type of fluid administered during peri-operative period to the study patients is shown in table 2. 10 of the 21 patients did not have any maintenance intravenous fluid administered during pre-op starvation period (night before surgery until time of surgery). Patient 11 had one unit of blood transfused the night before surgery.

### Figure 4

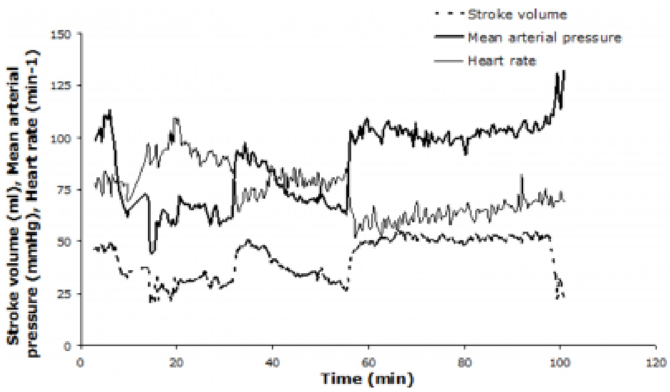
Table 2: Peri-operative fluid management in 21 patients. Values are mean [range] volume in ml.

| Type of fluid | Pre-operative fluid* | Intra-operative fluid |
|---|---|---|
| Crystalloid | 352 [0 – 1000] | 845 [0 – 2000] |
| Colloid | 0 | 943 [0 – 2000] |
| Total | 352 [0 – 1000] | 1788 [800 -3000] |

Administration of vasoconstrictors produced a range of responses (Figure 3). Two patients received metaraminol and ephedrine, five patients received only ephedrine and one patient received phenylephrine only. Responses were variable. Metaraminol appeared to have a more pronounced effect on blood pressure stroke volume and systemic vascular resistance than ephedrine in one patient. The effect of ephedrine on cardiac output was mainly through the increase in heart rate in the same patient (Figure 3).

### Figure 5

Figure 3: Response to the administration of vasoconstrictors. Short arrow indicates ephedrine 6 mg administration, long arrows indicate administration of metaraminol 0.5 mg in patient 19.




Four patients received intravenous ketamine for pain relief prior to positioning. The dose of 1 mg/kg in one patient and of 0.5 mg/kg in another patient resulted in a 20% increase in systemic vascular resistance accompanied by a 10% rise in systolic pressure. The other parameters remained unchanged. We observed no cardiovascular changes in the remaining two patients who received 0.5 mg/kg of ketamine each.

## DISCUSSION

Our findings suggest that regional anaesthesia for the repair of fractured neck of femur can be associated with significant changes in cardiac output. Hip fracture patients are an elderly hospital population who are at high risk of perioperative complications. This group of patients may not have the physiological reserve to satisfy the demand of the substantial increase in cardiac output generated by the trauma of the hip fracture and major surgery that follows it. We observed reduction in stroke volume and cardiac output by 15% and 20% respectively after establishment of regional anaesthesia in the study patients (Figure 1). In addition systemic vascular resistance decreased by 22% (Figure 2). The decrease in cardiac output is likely to be caused by reduced preload initiated by a decrease in venous return, which may be aggravated by preoperative dehydration. Preoperative dehydration, unless profound, is difficult to diagnose on clinical grounds or when using routine peri-operative haemodynamic monitoring [6]. Monitoring of cardiac output is likely to help optimal management of this high risk group of patients.

Patients with fractured neck of femur often have depleted intravascular volume in the perioperative period and rarely receive neither invasive haemodynamic monitoring nor high dependency care [6]. Furthermore, this group of patients are likely to be inadequately fluid resuscitated during perioperative period as the clinicians often fear that giving excessive fluid will precipitate left ventricular failure [17]. The patients with femoral neck fracture are frequently hypovolaemic on admission to hospital due to inadequate fluid intake often associated with immobility following fracture and dementia. This is likely to adversely affect tissue perfusion with consequent increase in postoperative morbidity and duration of hospital stay. On the other hand, heart failure is the second most common postoperative complication after hip fracture [18]. Close physiological monitoring in the perioperative period is likely to be beneficial [19] by optimising cardiac output and reducing postoperative cardiac failure in this group of patients. Current evidence suggests that fluid administration guided by the cardiac output monitoring leads to reduction in recovery time and time to being fit for discharge in patients with fractured neck of femur [67]. The average volume administered to the patients during operation in our study was 1788 mls. Maintenance intravenous fluids were not routinely prescribed to the study patients during preoperative starvation period (Table 2). It is quite likely that the initial drop in cardiac output observed in our patients during the first few minutes of regional anaesthesia could have been alleviated by the fluid resuscitation guided by the close observation of the changes in stroke volume before administration of regional anaesthesia.

We observed a number of responses to the administration of vasoconstrictors to our study patients. Generally changes in systemic vascular resistance, stroke volume and heart rate were commonly observed to a variable degree after administration of different vasoconstrictors (Figure 3). Administration of vasoconstrictors seems to be reasonable first line treatment of the cardiovascular effects of regional anaesthesia. A small degree of head down tilt has also been suggested [20]. Influence on spinal spread after intrathecal injection, even with 30 degrees tilt, is likely to be minimal [20]. The stroke volume on the other hand might rise considerably [20]. The anaesthetists in charge of our study patients did not use head down tilt for any of our study patients.

Positional changes of the patient before and after administration of regional anaesthetic as well as transfer from the anaesthetic room to theatre, for which LiDCO monitoring had to be interrupted, may have led to erroneous single readings of the LiDCO. We concentrated on the interpretation of the trends in cardiovascular variables obtained from the LiDCO. It is recognised that when using monitors that rely on the pulse contour analysis, absolute levels of cardiac output cannot be established with certainty [18]. Trend changes in the cardiovascular variables are likely to be more accurate than the absolute numbers [18]. Anaesthetists in charge used isobaric bupivacaine in 5 patients and hyperbaric bupivacaine in 16 patients. We were unable to standardise for the type of bupivacaine used due to the observational nature of our study. We are aware that the number of patients we studied is too small to make definitive conclusions. However, this is the first study that looks at the cardiac output changes in patients admitted for emergency surgery for repair of the neck of femur fracture using LiDCO cardiac output monitor. Larger studies are needed to further evaluate the findings observed in this study.

Regional anaesthesia is the preferred anaesthetic technique for surgery to a fractured neck of femur among the anaesthetists in the United Kingdom [3]. However, effects of regional anaesthesia and surgery on the cardiovascular system appear difficult to quantify [8910111213222232425]. Casati and colleagues [8] looked at the haemodynamic changes after spinal and epidural anaesthesia in 32 ASA I and II orthopaedic patients scheduled for hemiarthroplasty or Ender nailing. Heart rate and cardiac index were reduced in the spinal group only, but no changes in stroke volume, left ventricular stroke work or systemic vascular resistance were observed in either group. However, other researchers have found a decrease in systemic vascular resistance and no change in cardiac output in patients having spinal anaesthesia for transurethral resection of prostate [2223]. This drop in systemic vascular resistance was solely responsible for the hypotension after spinal anaesthesia [2223]. Similarly Rooke and colleagues [24] concluded from their study on 11 patients with significant cardiac disease that the primary mechanism of hypotension was a drop in systemic vascular resistance and not in cardiac output. In contrast, Zaugg and colleagues [25] reported a 25% drop in stroke volume and a 20% drop in cardiac output due to a marked decrease in venous return. They found systemic vascular resistance to be unchanged. Meyhoff and colleagues [13] have conducted similar study using a LiDCO monitor on 31 elective patients scheduled for lower limb surgery. The data collection in this study was limited to the pre-surgery time, averaging 17 minutes, with five patients having data collection over a period of only 11 minutes. Given the elective nature of surgery and limited observation time, it is not surprising that the cardiac output changes in the Meyhoff paper were less significant (10% versus 20% in our paper). Asehnoune and colleagues [9] looked at the cardiac output changes in 32 patients admitted for variety of elective surgical procedures, including lower limb surgery, requiring spinal anaesthesia. They used thoracic impedance as their cardiac output monitor and recorded cardiac output intermittently on three occasions: 2, 10 and 30 minutes after intrathecal administration of local anaesthetic. Significant limitation of their study, by their own admission, is that cardiac output measurements may not have been accurate 'because of interference caused by changes in electrode position'. Similarly, Kamenik and colleagues [10] used thoracic impedance to look at the effect of lactated Ringer's solution on cardiac output changes in elective patients scheduled for lower limb surgery under spinal anaesthesia. Although the researchers claim not to have moved the patient during the study period it is likely that this study was compounded by the same limitation as the Asehnoune study [9]. Critchely and Conway [12] used thoracic impedance cardiac output monitor to look at the haemodynamic effects of colloid and metaraminol administration in 45 patients who received spinal anaesthesia for neck of femur fractures. They concluded, in agreement with our findings, that administration of vasoconstrictor is likely to be more effective than administration of colloids in managing heamodynamic changes during spinal anaesthesia for the repair of fractured neck of femur. So far it remains unclear whether cardiovascular changes after general anaesthesia are of the same nature and magnitude. Further studies are needed to compare the two techniques.

The difference in the reported cardiovascular changes induced by the administration of regional anaesthesia emphasises the unpredictability of the way this population of patient is likely to respond to anaesthesia and surgery. There seems to be a wide variation in the degree of dehydration and cardiac morbidity that this group of patients presents with, emphasising the importance of precise monitoring during perioperative period to enable adequate but not excessive fluid administration.

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## Author Information

**J. Brombacher**
Consultant Anaesthetist, Aberdeen Royal Infirmary

**I. Hodzovic**
Senior Lecturer, Department of Anaesthetics, Royal Gwent Hospital

**S. Ridgway**
Consultant Anaesthetist, Royal Gwent Hospital

**T. Mian**
Consultant Anaesthetist, Royal Gwent Hospital

**J. Mecklenburgh**
Non-Clinical Senior Lecturer, Department of Anaesthetics, School of Medicine, Cardiff University