ABSTRACT

Introduction: Femoral nerve blockade is commonly used as analgesia in patients with a fractured neck of femur. The relationship of the femoral nerve in relation to the femoral artery is thought to change after a fractured neck of femur. We hypothesised that a fracture of the femoral neck would result in an increase in the distance from the mid-point of the femoral nerve to the mid-point of the femoral artery, due to lateral displacement of the femoral nerve.

Materials and methods: We conducted an assessor-blinded observational study to investigate the position of the femoral nerve in relation to the femoral artery and skin in 27 patients with fractured neck of femur, using the non-fractured side as a within subject control.

Results: There were no statistically significant differences between the fractured and non-fractured sides with regard to artery-nerve distance [18.0 mm (0.4) on the side of the fracture and 16.7 mm (0.4) on the non-fractured side (p = 0.255)] or distance from the mid-point of the femoral nerve to the skin surface [16.6 mm (0.5) on the fractured side and 16.9 mm (0.5) on the non-fractured side (p = 0.802) (mean (SD)].

Conclusion: There appear to be no clinically relevant changes in landmark position of the femoral nerve, at the level of the inguinal ligament, following hip fracture.

Keywords: Fracture, Neck, Femur, Femoral, Nerve, Ultrasound.


Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Around 70,000 patients in the United Kingdom were admitted to hospital following hip fracture in 2010/2011. These patients often have multiple comorbidities and place a huge burden on the health service with a median patient length of stay of 21 days and a total of just over 1.6 million in-patient bed days each year. This equates to a cost in excess of £1.1 billion to the National Health Service, a figure which is thought to double when taking into account the cost of social care for these patients. Postoperative mortality after surgical repair of a fractured neck of femur is 5 to 10% at 30 days and 19 to 33% at 1 year.

Effective peri-operative analgesia, with minimal systemic side effects, is an important component in the management of these patients. Local anaesthetic femoral nerve blockade can provide effective pre-, intra- and post-operative analgesia. Whilst there is currently insufficient evidence to show an improved long-term outcome following the use of femoral nerve blocks in patients with a fractured neck of femur, there is evidence to show that femoral nerve block provides analgesia more rapidly than systemic analgesics and reduces opioid requirements, with a low incidence of complications.

Performance of a femoral nerve block relies upon the identification of anatomical landmarks. In most instances the nerve is located using its relationship to the femoral artery, either by surface palpation and nerve stimulation, or by visualisation of the artery and nerve with ultrasound. Following proximal femoral fracture there may be external rotation of the leg and fracture related tissue swelling (secondary to haematoma or oedema), both of which may cause an increase in the distance separating the femoral artery and nerve.

We used ultrasound imaging to investigate how the anatomical position of the femoral nerve was altered after a fractured neck of femur. We hypothesised that a fracture of the femoral neck would result in an increase in the distance from the mid-point of the femoral nerve to the mid-point of the femoral artery, due to lateral displacement of the femoral nerve.

MATERIALS AND METHODS

The study was granted ethical approval by the Nottinghamshire Ethics Committee and all patients gave written informed consent. We conducted a prospective, single-centred, observational study involving participants with a neck of femur fracture between November 2010 and December 2010. Thirty patients aged 53 to 92 years, who were awaiting surgical repair of fractured neck of femur, were recruited with the following exclusion criteria: previous surgical repair of a hip fracture; inability to provide informed consent; and the inability to lie supine for an ultrasound examination.

The study took place on the orthopaedic ward, with the participant supine in their hospital bed. The participant was allowed to leave their legs in whatever position they felt most comfortable. Ultrasound images of the femoral nerve were obtained from both the fractured and non-fractured
An Ultrasound Study of the Anatomical Position of the Femoral Nerve in Patients with a Fractured Neck of Femur

The conduct of the ultrasound scan was identical for all subjects, with the non-fractured side always imaged first, and all scans performed by the same investigator. A Sonosite® S-Nerve machine (Sonosite Inc, Bothell, WA, USA) was used in conjunction with a 38 mm high frequency linear probe. This probe generates a beam 38 mm wide and 1 mm thick and can provide a depth of view between 1.8 and 6 cm. The probe was covered with a Tegaderm™ dressing to prevent the spread of infection and Aquagel® lubricating jelly (Ecolab UK, Leeds, UK) was applied to the probe and the participant’s skin to facilitate acoustic coupling of the probe and skin. The ‘nerve’ preset on the Sonosite® S-Nerve was used to optimise the ultrasound beam characteristics for visualisation of nervous tissue and the highest frequency setting (6-13 MHz) that gave the clearest view of the femoral nerve was used.

The femoral nerve and artery were visualised at the level of the inguinal ligament and a screenshot of the image was stored electronically (Fig. 1A).

The ultrasound images were subsequently anonymised and given a random identification number by a member of the research team who was not involved in the image analysis. The images were imported into Microsoft Office 2007 PowerPoint (Microsoft Corporation, Redmond, VA, USA) and were reviewed independently by two blinded members of the research team. The nerve and artery were outlined and two perpendicular lines were drawn through the outline defining their maximal height and width; the intersection was taken as the mid-point of the nerve or artery. The distance between the mid-points of the nerve and artery, and the distance from the skin to the mid-point of the femoral nerve, were then measured (Fig. 1B).

A small previous study using MRI to image the femoral nerve demonstrated a mean distance of 9.64 mm between the mid-points of the femoral artery and nerve. We calculated that 27 subjects acting as their own control would be required to show a 33% increase in nerve-artery distance with a power of 0.8. To allow for a drop-out rate of 10% we therefore aimed to recruit 30 subjects. Statistical analyses were performed using SigmaStat 3.1 software (Systat Software, Richmond, CA, USA). Following testing for normality, the difference in nerve-artery and nerve-skin distances between the two sides were compared using paired t-tests. p < 0.05 was considered significant.

RESULTS

Fifty-six patients were assessed for inclusion into the study. Thirty-three patients met the eligibility requirements and three patients declined to participate. Thirty patients were enrolled and underwent ultrasound imaging. The images from three patients were deemed unsatisfactory, as the femoral nerve was not identifiable at the bedside. These patients were excluded leaving 27 subjects for analysis (Fig. 2). The characteristics of the participants are shown in Table 1.

At the level of the inguinal ligament the distance between the mid-point of the femoral nerve and femoral artery was 18.0 mm (0.4) on the side of the fracture and 16.7 mm (0.4) on the non-fractured side (p = 0.255). The distance from the mid-point of the femoral nerve to the skin surface was 16.6 mm (0.5) on the fractured side and 16.9 mm (0.5) on the non-fractured side (p = 0.802). All values are mean (SD).

Inter-observer reliability of the measurements obtained by the two observers was good. The mean difference...
between measurements obtained by the two observers was 1.88 mm (2.55) on the side of the fracture and 1.10 mm (2.96) on the non-fractured side. All values are mean (SD).

**DISCUSSION**

We have demonstrated that a fracture of the femoral neck causes no clinically significant alteration in the horizontal distance between the femoral nerve and femoral artery at the level of the inguinal ligament. Similarly a fractured hip was not associated with any change in the perpendicular distance between the femoral nerve and surface of the overlying skin.

It has been hypothesised that hip fractures may disrupt the inguinal anatomy, and in particular alter the position of the femoral nerve relative to the femoral artery and the skin due to the external rotation of the affected leg and local tissue oedema and haematoma secondary to the fracture. An ultrasound study involving the passive external rotation of the legs of healthy volunteers, demonstrated an increase in the artery-nerve distance and a decrease in the skin-nerve distance. However, this passive rotation does not accurately mimic the external rotation seen after hip fracture: after a fracture bony anatomical distortion may not be transmitted to the soft tissues in the proximal thigh and groin.

Similarly, it may be that the patients in our study only displayed a minimal degree of external rotation after their fractured neck of femur. We did not measure or assess formally the degree of external rotation of the fractured limb of our participants in order to minimise the chances of causing pain or discomfort. However, by performing the ultrasound in the position most comfortable for the patient, we have identified the nerve in the position where a femoral nerve block is most likely to be performed for analgesic purposes.

Despite the increasing incidence of hip fracture and the expansion of interest in regional techniques for these high-risk patients, there is only a single study that has previously investigated the position of the femoral nerve after hip fracture, with results contradictory to our own. This small study of 10 patients measured the position of the femoral nerve relative to the artery at the mid-inguinal ligament and the mid-inguinal crease using MRI. The authors were able to show a small (mean 2.86 mm), but statistically significant decrease in the nerve-artery distance at the mid-inguinal ligament. MRI images allow for a greater precision in the measurement of distance, but an alteration in position of less than 3 mm is unlikely to be of any clinical significance when undertaking femoral nerve blocks or nerve sheath catheter insertion. We chose ultrasound as our imaging modality for two reasons. First, ultrasound guidance is a recognised technique for performance of a femoral nerve block and therefore clinically relevant. Secondly, at a practical level ultrasound allowed for minimal disruption to the patient as it could be carried out as a bedside test.

We were unable to identify the femoral nerve, using ultrasound, in three of the participants (10%). The femoral nerve can be difficult to visualise as it displays a high degree of anisotropy. Our failure rate is in a similar range as previous studies involving hip fracture patients where investigators have been unable to visualise the femoral nerve in 5% of cases.

The level at which to perform a femoral nerve block is debated. Previous studies utilising the landmark based

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**Table 1: Characteristics of study participants**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>27</td>
</tr>
<tr>
<td>Age (mean (SD))</td>
<td>76 (12)</td>
</tr>
<tr>
<td>Females (%)</td>
<td>17 (63)</td>
</tr>
<tr>
<td>Height (cm) (mean (SD))</td>
<td>165 (12)</td>
</tr>
<tr>
<td>Weight (kg) (mean (SD))</td>
<td>65 (14)</td>
</tr>
<tr>
<td>BMI (mean (SD))</td>
<td>24 (4)</td>
</tr>
<tr>
<td>Time from admission to ultrasound scan (h) [median (IQR)]</td>
<td>15 (10-21)</td>
</tr>
<tr>
<td>Left-sided fracture (n, %)</td>
<td>17 (63)</td>
</tr>
<tr>
<td>Intracapsular fracture (n, %)</td>
<td>17 (63)</td>
</tr>
</tbody>
</table>

BMI: Body mass index; SD: Standard deviation; IQR: Interquartile range.
approach have suggested that the inguinal skin crease is preferable to the inguinal ligament, as the nerve is in closer proximity to the femoral artery at this point providing a useful landmark. However, there are advantages to a more proximal approach, with femoral nerve blocks performed near to the inguinal ligament. The nerve is a more distinct structure at the inguinal ligament (making ultrasound visualisation easier) compared to the inguinal skin crease, where it has divided into branches to become a flatter structure. In addition, the femoral artery is also more likely to be located superficially to the femoral nerve at the inguinal skin crease, or give rise to the lateral circumflex femoral artery which runs laterally and superficial to the femoral nerve, increasing the risk of vascular puncture. It could be argued that our findings are less important now that ultrasound-guidance for femoral nerve blockade is becoming more common place in anaesthesia. However, the use of ultrasound is certainly not ubiquitous with most emergency departments and developing countries still using a traditional landmark approach for the procedure.

Our work is limited by the fact that we have only visualised the femoral nerve and not made any intervention. The ultrasound appearance of the nerve is of interest, but the key clinical facet is the ability to successfully perform a femoral nerve block. Rather than taking the mid-point of the nerve as the measurement index, future work could involve the performance of an ultrasound guided nerve femoral nerve block, and take the position of the needle tip as the measurement point. This has the added advantage of definitively identifying that the visualised structure is indeed the femoral nerve, through either the use of nerve stimulation or the development of anaesthesia.

SUMMARY AND CONCLUSION

We have demonstrated that a fractured neck of femur does not result in an alteration of the femoral nerve position relative to the femoral artery at the level of the inguinal ligament. This information may assist clinicians perform successful femoral nerve blocks when an anatomical landmark technique is utilised.

REFERENCES


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