SPECIALTY UPDATE

Iatrogenic vascular injuries during arthroplasty of the hip

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Vascular injuries during total hip arthroplasty (THA) are rare but when they occur, have serious consequences. These have traditionally been managed with open exploration and repair, but more recently there has been a trend towards percutaneous endovascular management.

We performed a systematic review of the literature to assess if this change in trend has led to an improvement in the overall reported rates of morbidity and mortality during the last 22 years in comparison with the reviews of the literature published previously.

We found a total of 61 articles describing 138 vascular injuries in 124 patients. Injuries because of a laceration were the most prevalent (n = 51, 44%) and the most common presenting feature, when recorded, was bleeding (n = 41, 53.3%). Delay in diagnosis was associated with the type of vascular lesion (p < 0.001) and the clinical presentation (p = 0.002).

Open exploration and repair was the most common form of management, however percutaneous endovascular intervention was used in one third of the injuries and more constantly during the last 13 years.

The main overall reported complications included death (n = 9, 7.3%), amputation (n = 2, 1.6%), and persistent ischaemia (n = 9, 7.3%). When compared with previous reviews there was a similar rate of mortality but lower rates of amputation and permanent disability, especially in patients managed by endovascular strategies.

Cite this article: Bone Joint J 2015;97-B:1447–55.
The results of the searches were merged into one list by selecting only those articles that contained at least one keyword from each search. This refined our search to only those articles describing any form of vascular injury in association with any form of hip surgery.

Following this, the titles and abstracts of the shortlisted articles were reviewed to ensure the inclusion of only those that described vascular injuries in association with hip arthroplasty, including resurfacing arthroplasty and revision THA. We excluded case reports relating to hemiarthroplasty or internal fixation for fractures of the hip and vascular injuries following the dislocation or reduction of an arthroplasty. Articles describing post-operative deep vein thrombosis (DVT) or vessel injuries caused by procedures performed in conjunction with hip arthroplasty, such as adductor tenotomy, were also excluded. The references of all the articles identified were then searched for any more publications that could have been missed by the searches on the selected databases (Fig. 1).

The final selection of articles were systematically reviewed using the same methods as described previously. The data gathered were divided into four categories. In the first category we recorded patient demographic details and information relating to the operation including the type of surgery; primary or revision, laterality and the approach used. In the second category we focused on the type of the vessel injured (when specified we recorded whether it was a branch or a main vessel), the type of lesion, the presenting clinical features and the delay in diagnosing the injury from the time of surgery. In the third category we recorded information on the management and the complications relating to the vascular injury including death, persistent ischaemia, or neurological deficit. Whenever endovascular management was used, the specific type of intervention was recorded. In the fourth category we recorded the associated risk factors for vascular injury which were reported such as infection, migration of the components and a history of previous vascular disease.
The delay to diagnosis was divided into four intervals as proposed by Lazarides et al. during or within the first 24 hours of surgery, one month, one to 12 months and > one year later. Several case reports contained a precise description of the time delay to diagnosis. This enabled us to divide the second interval into two categories, a diagnosis established within the first week of injury and diagnosis between the first week to one month of surgery.

**Statistical analysis.** Descriptive analysis of the cases is presented. We mainly used contingency tables (cross tabulation) to present our data and therefore the chi-squared test (or Fisher’s exact test) was used to test for statistical differences between the different categories. A p-value < 0.05 was considered significant. Cases with missing data were excluded from the reported percentages in the results, i.e., percentages are based on valid data only. However any missing data is presented in the tables and included in the figures (graphs) unless it is mentioned otherwise.

### Results

A total of 61 articles\(^4,11,13,15-72\) were identified; 51 individual case reports and ten case series. These articles reported a total of 124 vascular injuries involving 138 blood vessels, as more than one vessel was injured in some patients. Some of the reports lacked specific information on the gender of the patients (\(n=36, 29\%\)) or the side of the surgery (\(n=55, 44.3\%\)). This lack of information was mainly encountered in case series. However, the vast majority of the reports (\(n=116, 93.5\%\)) adequately reported the type of blood vessel that was injured and the management which was undertaken (\(n=113, 91.1\%\)).

The mean age of the patients was 65 years (36 to 87) and almost two thirds (\(n=55, 62.5\%\)) were women. Vascular injury in primary THA accounted for more than half (\(n=68, 54.8\%\)) of the cases (Table I).

Injuries have been reported in all the main vessels around the hip with the common femoral artery being the most commonly reported injured vessel (Fig. 2). Generally, there were more vascular injuries in women and involving the left hip. More specifically, the external iliac and the common femoral arteries were more commonly injured in women (\(p=0.021, \text{chi-squared test}\)). There was no association between the type of blood vessel injured and the surgical approach (\(p=0.21, \text{chi-squared test}\)). The search of the literature did not identify case reports of vascular injuries associated with the anterior approach of the hip. There was also no association between the type of blood vessel injured and the type of surgery (primary vs revision, \(p=0.36, \text{chi-squared test}\)). However, in four of the six hip resurfacing procedures, the superior gluteal artery (or one of its branches) was injured. Penetration or laceration (acute or chronic) to blood vessels was the most prevalent form of injury (\(n=51, 44.0\%\) (Fig. 3).
The most common presenting feature (when reported) was bleeding (occult or frank haemorrhage including shock); \( n = 41, 53.3\% \) (Table II, Fig. 4). Two thirds of the injuries \( n = 80, 68.4\% \) were diagnosed during surgery or within the first post-operative week (Fig. 5). The delay to diagnosis was associated with the type of the lesion \( (p < 0.001, \text{chi-squared test}; \text{Fig. 6}) \), and the clinical manifestation \( (p = 0.002, \text{chi-squared test}; \text{Table II}) \). One case of vascular injury at primary THA was detected 18 months later, during pre-operative assessment for revision surgery.\(^4\) In another case,\(^7\) pre-operative imaging for revision surgery showed the close proximity of a migrated acetabular screw to the external iliac vein which alerted the surgeons to take appropriate precautions and the vessel was not injured. Hence, this case was not included in our analysis. In two patients with a false aneurysm, which was not attributed to the previous primary THA, the diagnosis was not made until they bled intra-operatively during revision surgery.

Open exploration, for repair, thrombectomy or ligation, was the most common intervention used for all vessels (arteries and veins) (Fig. 7). Percutaneous endovascular intervention was used in a third \( (n = 41, 36.6\%) \) of the arterial injuries (Fig. 8); mainly during the last 13 years. During the last ten years, of the 59 arterial injuries reported, 29 (49\%) (in 24 patients) were managed by endovascular interventions, in comparison to 12 (24\%) of 50 during the preceding ten-year period. Percutaneous intervention \( (n = 41 \text{ over a 22-year period}) \) in arterial injuries was mainly carried out to embolise bleeding arteries or their branches \( (n = 30, 73.2\%) \). Angioplasty \( (n = 1, 2.4\%) \) and endovascular stenting or grafting of main arteries \( (n = 10, 24.4\%) \) were also used. Grafts were used in eight of 27 (29.6\%) injuries to the external iliac artery (six with false-aneurysm and two with occlusion by direct external compression) and in one (4.2\%) false-aneurysm of the common femoral artery. The remaining injuries \( (n = 42) \) involving these two main vessels were managed with an open procedure.

Many of the reports did not specify the precise cause of the injuries, but 11 (8.9\%) were documented as being caused by migrating components and seven (5.6\%) were associated with infection. A total of ten (8.1\%) were associated with both the migration of a component and infection.

The complications which were reported included death in nine (7.3\%), amputation in two (1.6\%) and persistent ischaemia in nine (7.3\%) patients. Additionally, four (3.4\%) other complications included stroke \( (n = 2) \) and pulmonary embolism \( (n = 2) \). When endovascular intervention was used for arterial injuries, \( (n = 36 \text{ patients}) \) there were three (8.3\%) reported deaths \textit{versus} six (8.7\%) when open exploration \( (n = 69) \) was used \( (p = 0.630, \text{Fisher’s exact test}) \), and no reported case of amputation \( (0 \text{ vs} 2 \text{ respectively} (2.9\%); p = 0.430, \text{Fisher’s exact test}) \) or persistent ischaemia \( (0 \text{ vs} 9, \text{respectively} (13\%); p = 0.019, \text{Fisher’s exact test}) \).

**Discussion**

Historically, the risk of vascular injury during THA was estimated to be between 0.16\% and 0.25\%\(^5\) but recently in a large series of > 13 000 cases, Abularrage et al\(^7\) reported an incidence of 0.04\% in primary THA increasing to...
0.19% in revision surgery. Others estimate the risk of vascular injury during primary THA to be approximately 0.09%.12,16 It has been suggested that each orthopaedic surgeon might encounter at least one vascular injury every 14 years of their practice.38

The common femoral and the external iliac vessels have consistently been reported to be the most commonly injured vessels during arthroplasty of the hip,8,10 which is in agreement with our findings. The external iliac artery and vein lie only 7mm away from the bone at the level of anterior inferior iliac spine2 and sometimes lie directly on the osseous surface3 as they leave the cavity of the pelvis. Hence, these vessels are at a high risk of injury3 by excessive medial placement of a retractor,6 or penetration by a screw
used for fixation of the acetabular component.\textsuperscript{1,4,21} Similarly, the common femoral artery and vein are only separated from the capsule by iliopsoas,\textsuperscript{2} rendering these vessels at risk of damage from placement of a retractor\textsuperscript{2,6} especially during the anterolateral approach to the hip. The superior gluteal artery was the most common vessel injured in resurfacing arthroplasty. The reports on these injuries do not mention the exact cause of the injury but a possible cause could be penetration from a screw placed in the acetabulum.\textsuperscript{11,13}

Blood vessel injuries during THA, have been associated with significant complications.\textsuperscript{37,44,58,59} In a review that included > 94 arterial injuries following arthroplasty of the hip, a mortality rate of 9\%, amputation of 12\%, and of

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**Fig. 6**

Graph showing the delay in diagnosis and the type of blood vessel lesion; \( p < 0.001 \). 15 cases were excluded because the type of the lesion and or the delay to diagnosis was not recorded.

**Fig. 7**

Graph showing management strategies used for all vessels injured (arteries & veins) *open repair; this includes direct repair, repair with graft or with bypass graft. ** Percutaneous endovascular intervention; this includes angioplasty, embolisation, stenting or endovascular graft.

**Fig. 8**

Graph showing the proportion of percutaneous endovascular management vs open management strategies for arterial injuries over the last 20 years (categorised into five year intervals).
permanent disability of 17% due to ischaemia, were reported. Another reported a rate of mortality of 7% and a significantly higher rate of amputation (19%). In our review the rate of mortality was 7.8%, which is similar to and consistent with previous reports but the number of reported amputations and patients with persistent ischaemia were significantly lower; 1.8% and 8.1%, respectively.

The presenting clinical feature is determined by the mechanism of injury and the resulting lesion to the vessel, however, most papers did not specify exactly how the vessels were injured. Direct acute perforation by an instrument such as a retractor or scalpel accounts for most injuries. It is thought that the type of perforation of the vessel can determine the timing of the presentation. Longitudinal lacerations cause heavy bleeding intra-operatively and are mostly recognised immediately. Punctures, however, often cause a small amount of slow bleeding that results in the formation of a false aneurysm. These are commonly missed during surgery but manifest later because of haematoma formation, continual occult bleeding, or a pulsatile mass. Our review records considerable variation in the time to diagnosing a false aneurysm and is consistent with previous reports. Shoenfeld et al reported a mean delay to diagnosis of nine months for a false aneurysm. Others have reported a delay that ranged from five hours to 14 years. These late-presenting false aneurysms can present in three ways: a pseudo-aneurysm causing pain in the hip because of pressure; ischaemic symptoms in the affected limb due to impaired blood flow or distal microembolisation; and severe haemorrhage while extracting a component during revision surgery.

Another mechanism of direct injury is the chronic and slow erosion of a vessel by protruding screws, extruded cement or the migration of a loose component leading to the formation of a false aneurysm or thrombus.

An indirect injury can result from stretching of athro-sclerotic or calcified arteries causing intimal tears with subsequent thrombus formation. This may occur during manipulation of the joint or following restoration of centre of rotation in hips with chronic proximal migration of the femoral head or acetabulum. Another cause of indirect thrombus formation is thermal damage from the polymerisation of cement near to a blood vessel.

Our findings suggest that the characteristic presenting feature of some vascular injuries is associated with a delay to diagnosis. This is important because early recognition of vascular injuries may help in avoiding severe complications. The vast majority of injuries were diagnosed either immediately or within the first seven days of surgery. Bleeding (occult or frank) and ischaemia were the most common early presenting features in our review which is consistent with previous reviews. When allowing for the differences in the number of vascular injuries diagnosed between one and 30 days of surgery, the overall delay to diagnosis in our review is similar to previous experience (Fig. 9). Bleeding accounted for > 50% of the presenting features, indicating that a low threshold for angiography may be appropriate in patients with persistent bleeding and a drop in haemoglobin post-operatively.

Open intervention has been the main form of management in many of the old reviews and remains a common method to manage larger vessels and when bleeding occurs during surgery. Open procedures were used predominantly when a vascular injury was noted at the time of surgery, whereas endovascular techniques were more common for problems identified subsequently.

Nevertheless, it is clear that percutaneous endovascular intervention for embolisation or stenting has become more common during the last 13 years. The most common endovascular intervention reported was the embolisation of a terminal vessel and stenting of a wide-necked false aneurysm arising from a large blood vessel such as the external iliac and common femoral artery.

Endovascular techniques allow for faster recovery, low rates of complication and have a high probability of success.

**Pre-empting the risk of vascular injuries.** The high rate of injury in women and on the left side which has been reported, is consistent with our findings and possibly reflects the closer proximity of the blood vessels to the hip joint in these two categories. Hence left sided operations in women may be considered to be a risk factor for vascular injury. However Lazarides et al believe this risk has been over-estimated and consider other factors such as the type of surgery (i.e. revision) to be more important.

Migration of components and infection are recognised risk factors for catastrophic vascular injuries and in this scenario pre-operative vascular imaging is strongly recommended. The presence of a vascular
surgeon during revision of a migrated acetabular component is also recommended and in the event of intra-pelvic migration consideration should be given to using a retropertoneal approach. This allows the safe extraction of the component and facilitates vascular control should haemorrhage occur.\textsuperscript{7,76-78} Some authors have recommended routine pre-operative vascular imaging in revision surgery regardless of the presence of migration.\textsuperscript{2,25,73} They argue that many cases of vascular injuries may go unrecognised during primary surgery, or subsequently result from chronic erosion by cement spicules or protruding screws forming false aneurysms. These aneurysms pose a significant risk of bleeding during revision surgery.\textsuperscript{2,40,76}

Patients with atherosclerosis are at an increased risk of indirect injuries resulting in ischaemia.\textsuperscript{15,20,74} Although this is more likely to involve the vasculature immediately surrounding the hip joint,\textsuperscript{24,38,39} a rare case of infrarenal occlusion of the aorta following revision of an acetabular component in a patient with arterial disease has been described.\textsuperscript{14} In our review, four of the 18 patients with thrombotic lesions were reported to have peripheral vascular disease. We also found four patients in whom a synthetic vascular bypass graft occluded during surgery. Thus, patients with peripheral vascular compromise should undergo careful pre- and post-operative vascular assessment, especially those with weak or palpable distal pulses or a markedly low ankle brachial index (< 0.4).\textsuperscript{16}

In conclusion, vascular injuries during arthroplasty of the hip are rare and may have a devastating outcome if not managed appropriately. The type of arteries injured, the variety of lesions sustained and the presenting clinical features did not differ significantly from the previous reports. A third of the reported arterial injuries were managed by endovascular intervention techniques during the last 22 years which marks a change compared with the open exploration reported in previous series. However, disappointingly, the overall reported rate of mortality has remained similar, but the overall rate of amputations and persistent ischaemia has dropped significantly.

Author contributions:
Z. Alshameeri: Initiated, planned, conducted, analysed and wrote the project.
R. Rajakel: Initiated, planned, conducted, analysed and wrote the project.
K. Varty: Plan of review, manuscript revision.
V. Khanduja: Analysis, editing, final review.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

This article was primarily edited by G. Scott and first proof edited by J. Scott.

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