Anatomy of the terminal branch of the posterior circumflex humeral artery

RELEVANCE TO THE DELTOPECTORAL APPROACH TO THE SHOULDER


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Aims
Despite the expansion of arthroscopic surgery of the shoulder, the open deltopectoral approach is increasingly used for the fixation of fractures and arthroplasty of the shoulder. The anatomy of the terminal branches of the posterior circumflex humeral artery (PCHA) has not been described before. We undertook an investigation to correct this omission.

Patients and Methods
The vascular anatomy encountered during 100 consecutive elective deltopectoral approaches was recorded, and the common variants of the terminal branches of the PCHA are described.

Results
In total, 92 patients (92%) had a terminal branch that crossed the space between the deltoid and the proximal humerus and which was therefore vulnerable to tearing or avulsion during the insertion of the blade of a retractor during the deltopectoral approach to the shoulder. In 75 patients (75%) there was a single vessel, in 16 (16%) a double vessel and in one a triple vessel.

Conclusion
The relationship of these vessels to the landmark of the tendon of insertion of pectoralis major into the proximal humerus is described. Damage to these previously undocumented branches can cause persistent bleeding leading to prolonged surgery and post-operative haematoma and infection, as well as poor visualisation during the procedure.

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The deltopectoral approach is the standard approach for most operations involving the shoulder, both in elective and trauma cases. It is extensile and sited on an inter-neural plane between the axillary nerve and the musculocutaneous nerve. However, this exposure is sometimes accompanied by unexpected bleeding.

One source of this can be the deltoid artery and its branches. Another potential source is the terminal branch of the posterior circumflex humeral artery (PCHA), the anatomy of which has not been well described, making it susceptible to damage during this approach. Damage to this vessel can result in poor visualisation and risks post-operative haematoma formation and possible infection.

The terminal branch of this vessel is found in the subdeltoid recess as the PCHA travels anteriorly. This space is exposed in order to allow the insertion of retractors (Fig. 1) with one blade usually in the space between the deep surface of the deltoid muscle and the humerus. The terminal branch crosses this plane, and will commonly be torn either by the blade of the retractor or by blunt dissection.

The aim of this study was to document the anatomical variations of the terminal branches of the PCHA in relation to the pectoralis major tendon. The insertion of pectoralis major is a standard reference point which is encountered during the approach.

Patients and Methods
A prospective observational study was undertaken between January 2011 and June 2012 involving consecutive patients undergoing a deltopectoral approach to the shoulder. The inclusion criterion was any patient aged > 18 years undergoing this approach. Exclusion criteria were revision surgery, acute fracture surgery, because there is often a large haematoma, and previous local radiotherapy. This group of patients have been described in a previous study, detailing the anatomy of the deltoid artery. A total of 100 patients, 51 women and 49 men, were enrolled. The mean...
age of the patients was 65 years (standard deviation (SD) 17; 23 to 87). The right shoulder was involved in 54 patients and the left shoulder in 46. The indications for surgery are shown in Table I.

A standard approach was used with the patient in the supine position and the table in 10° of head-up tilt. The incision was made between the coracoid superiorly and about 2 cm lateral to the axillary crease distally. The interval between the deltoid and pectoralis major was carefully dissected and the superior border of the insertion of the tendon of pectoralis major was exposed. A retractor was inserted between the lateral shaft of the humerus and deltoid in the subdeltoid space, 1 cm above a line projected from the superior border of the insertion of pectoralis major. A second retractor was placed in a similar position, but 3 cm below the line projected from the superior border of the insertion of pectoralis major (Fig. 2a). The subdeltoid fascia was dissected from the lateral humeral shaft to expose the terminal branch of the PCHA as it entered the humerus. Any variations in the pattern of the terminal branches and their relationship to the superior border of the pectoralis major tendon were recorded, with the distance from the superior border being measured in millimetres using a sterile ruler.

Results
No patient developed a post-operative haematoma requiring drainage and none is known to have had any subsequent problems with perfusion of the humeral head.

In total, four main variations were discovered with subdivisions depending on whether the terminal branch was superior (group A) or inferior (group B) to the insertion of

Table I. Indications for surgery

<table>
<thead>
<tr>
<th>Cases (n)</th>
<th>Surgery</th>
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</thead>
<tbody>
<tr>
<td>52</td>
<td>Total shoulder arthroplasty</td>
</tr>
<tr>
<td>26</td>
<td>Reverse shoulder arthroplasty</td>
</tr>
<tr>
<td>7</td>
<td>Subscapularis repairs</td>
</tr>
<tr>
<td>6</td>
<td>Laterjet procedures</td>
</tr>
<tr>
<td>4</td>
<td>Capsular shift operations for instability</td>
</tr>
<tr>
<td>3</td>
<td>Eden Hybinette procedures</td>
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<tr>
<td>1</td>
<td>Humeral avulsion glenohumeral ligament repair</td>
</tr>
<tr>
<td>1</td>
<td>Hemiarthroplasty for osteonecrosis</td>
</tr>
</tbody>
</table>

Fig. 1
Illustration showing 1) terminal branch of the posterior circumflex humeral artery (PCHA) crosses the interneural plane and enters the humerus, just lateral to the insertion of pectorals major and 2) the PCHA and the axillary nerve traverse the quadrilateral space to travel around the back of the humerus and emerge on the deep surface of deltoid (Co, coracoid; D, deltoid; PM, pectoralis major).

Fig. 2a
a) Clinical photograph showing the position of the retractors. b) Angiogram demonstrating the posterior circumflex humeral artery (PCHA). TBPC, terminal branch of the PCHA; H, humerus; PM, pectoralis major.

Fig. 2b
pectoralis major. Type 0 variants had no terminal branch and comprised 8% of patients.

Type 1 variants (Fig. 2) had a single terminal branch and comprised 75% of patients; 45% had a type 1A terminal branch which was superior to the superior border of the insertion of pectoralis major and 30% had a type 1B terminal branch below the superior border of the tendon. Type 1B branches were a mean of 4.5 mm (SD 2.9, 0 to 12) below the insertion.

In total, 16% of patients had a type 2 variant with two terminal branches, superior and inferior. Of these variants most (63%, ten dissections) were type 2A with a superior terminal branch superior to the tendon and the remainder (37%, six dissections) were type 2B variants with a superior terminal branch inferior to the tendon (mean 4.4 mm, SD 3.1 mm, 0 to 10). The inferior branches of all the type 2 variants were well below the superior border of the tendon (mean 9.3 mm, SD 5.3 mm, 3 to 18).

There was one type 3 variant (1%) with three terminal divisions. The most superior branch was 8 mm below the tendon and the most inferior branch was 16 mm below it (Table II).

**Discussion**

The anatomy of the PCHA has been described many times.5-7 However, to our knowledge, the terminal branches crossing the space deep to deltoid to enter a nutrient pit in the humerus just lateral to the superior border of the insertion of the tendon of pectoralis major, have not been described. This vessel is important because of its vulnerability to the position of the blade of self-retaining retractors during the deltopectoral approach to the shoulder. Tearing a terminal branch with retractor blades rather than cautering it is a potential source of post-operative haematoma.

The classic studies on the anatomy of the PCHA5-7 are concerned with the perfusion of the humeral head following fracture and the sequelae of avascular necrosis. These studies highlight the perforating branches within the quadrilateral space and how they enter the calcar of the humerus and perfuse the head. Another study8 examines the passage of the artery through the quadrilateral space and how it can be compressed by fibrous bands.

The anatomy of the PCHA as it passes with the axillary nerve through the substance of the deltoid muscle has been examined and how it is vulnerable to percutaneous pinning during surgery for fracture,9 but did not identify the terminal branch. Nor did the work of Gardner et al10 concerning the vulnerability of the axillary neurovascular bundle to minimally-invasive plating of proximal humeral fractures, identify the terminal branch.

Pakonstantinou et al11 looked at the vasculature of the proximal humerus, but considered the intraosseous blood supply, rather than the extra-osseous vulnerability of the nutrient vessels. Chen et al12 also performed an anatomical study of the origins of the circumflex humeral arteries, but did not discuss their insertions.

We found that the PCHA usually has either one or two terminal branches and that a third of these will be distal to the insertion of the tendon of pectoralis major. Careful exposure of the subdeltoid space with reference to this tendon allows visualisation of the terminal branches as they run into the lateral humeral periosteum. Cauterising these vessels close to the humeral shaft is safe and does not risk injury to the distal section of the axillary nerve, which is intimately related to the inner surface of the exposed deltoid muscle.

In conclusion, we have identified and classified variations in the anatomy of the terminal branches of the PCHA, and their relationships to the tendon of the insertion of pectoralis major, one of the primary landmarks for the deltopectoral approach. This knowledge will help surgeons avoid unnecessary bleeding when using this approach in operations on the shoulder.

**Take home message:**

Surgeons should identify and cauterise the terminal branches of the PCHA as described to prevent intra- and post-operative complications.

**Author contributions:**

C. D. Smith: Data Collection, Data analysis, Writing the paper.
S. J. Booker: Writing the paper.
H. S. Uppal: Writing the paper.
T. D. Bunker: Concept, Performed surgeries, Data collection, Editing the paper.
J. Kitson: Performed surgeries.

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.

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