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The Use of a Multi-Level Brachial Plexus Approach to Safely Overcome Abnormal Venous Collaterals for Awake Upper Limb Surgery

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Summary

In this case report we describe abnormal venous collateral circulation secondary to a radiocephalic arterio-venous (AV) fistula surrounding the brachial plexus of an extremely frail gentleman booked for complex upper limb surgery.

The venous collaterals surrounded the brachial plexus at multiple levels (supraclavicular, infraclavicular, axillary) precluding the safe performance of a single level brachial plexus approach, and the gentleman's extensive co-morbidities meant any conversion to a general anaesthetic would carry a significant risk of morbidity and mortality.

Initially an infraclavicular brachial plexus block was performed, however multiple collateral veins limited safe needling and local anaesthetic (LA) spread to the medial cord. A pre-scan of the axillary approach had also revealed multiple venous collaterals, but these were mainly located inferior to the axillary artery with relative sparing around the ulnar and median nerves. Armed with this knowledge a subsequent axillary brachial plexus block was preformed to selectively target the unobstructed median and ulnar nerves supplied by the medial cord. Total anaesthesia of the arm was achieved with awake surgery successfully completed.

Keywords: Awake upper limb surgery. Infraclavicular Nerve Block (complications), Ultrasound Anatomy (Infraclavicular Nerve Block).

Introduction

Awake regional techniques for upper limb orthopaedic surgery have become increasingly popular in recent years, with brachial plexus blocks also demonstrating improved medium-term arterio-venous (AV) fistula patency in dialysis patients [1].

This case report describes the conduct of awake upper limb surgery under regional anaesthesia, in a patient with challenging sono-anatomy, due to significant venous collateral circulation in the operative arm surrounding the brachial plexus. The planned surgery was multifaceted, involving orthopaedic and transplant surgeons.

The patient had suffered a fracture to the mid-shaft of the left radius following a fall from a standing height at home. Complicating this fracture was the presence of an overlying AV fistula. Therefore, prior to performing an open reduction and internal fixation (ORIF) this overlying radiocephalic AV fistula required tie off, with the subsequent creation of a new brachiocephalic AV fistula post ORIF.

Pre-operative assessment of the patient revealed a poor functional baseline with multiple cardiac, respiratory and renal co-morbidities. He was deemed ASA 4 and high risk for a general anaesthetic (GA), with an awake regional technique the preferred option.

The aim of this case report is to highlight the potential difficulties encountered when performing a brachial plexus block in a patient with a pre-existing long-term AV fistula, causing multiple venous collaterals surrounding the brachial plexus, which limited needle advancement and LA spread. A thorough pre-scan at all levels of the brachial plexus (supraclavicular, infraclavicular and axillary), paired with applied anatomical knowledge was essential to develop a successful strategy to ensure all relevant branches of the brachial plexus were successfully blocked for the awake surgery to proceed uneventfully.

Report

A 84-year-old male was admitted with a mid-shaft fracture of his left radius following a fall at home. The fracture was complicated by an overlying radiocephalic fistula used to provide intermittent haemodialysis for end stage renal disease. Other co-morbidities included hypertension, congestive cardiac failure, atrial fibrillation and liver cirrhosis. He had a poor functional baseline and was noted to be short of breath at rest during pre-operative work-up. A nephrology review diagnosed fluid overload, and he was treated with an additional session of preoperative haemodialysis.

The patient was scheduled as a joint case, involving both transplant and orthopaedic surgeons. The surgical plan involved tying off the overlying radiocephalic fistula and an ORIF of the underlying radial fracture through a distal incision, followed by formation of a new brachiocephalic fistula through a second proximal incision in the antecubital fossa (Image 1).

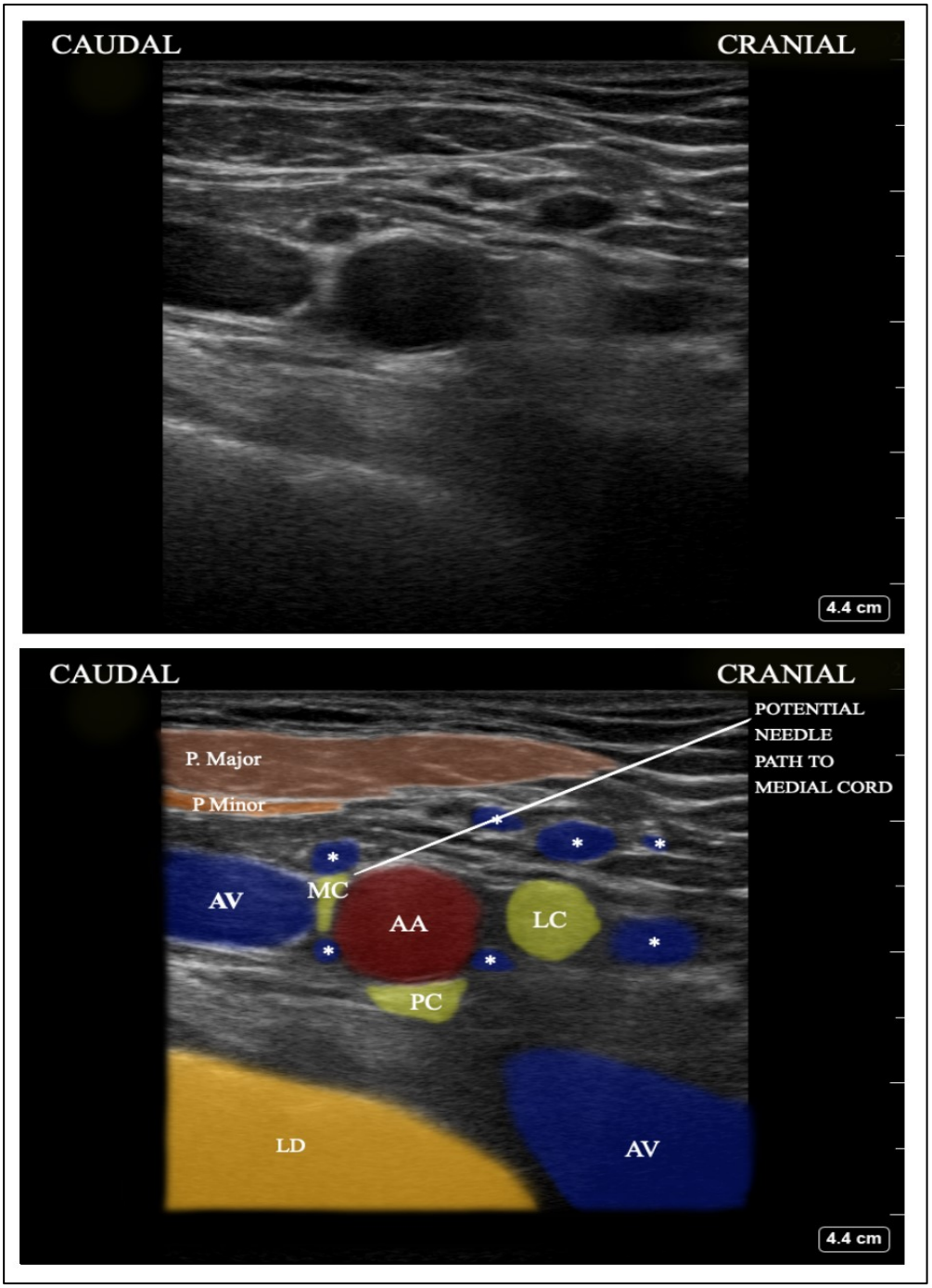

Image 1: Ultrasound images of this patient's parasagittal infraclavicular approach to the brachial plexus. Original above and annotated image below showing multiple partially compressed venous collaterals (*) overlying the potential needle path to the medial cord.

Key: AA= Axillary Artery, AV= Axillary Vein, LC= Lateral Cord, PC= Posterior Cord, MC= Medial Cord, LD= Latissimus Dorsi, P.Major= Pectoralis Major, P.Minor= Pectoralis Minor.

Image 2: An image of the patient's forearm 2 weeks post-surgery. Two surgical incisions are seen: the antecubital fossa incision for the new brachiocephalic fistula, and the distal forearm incision for the radiocephalic fistula tie-off and ORIF radius. The white dressing covers the puncture marks from his first successful haemodialysis session postop via the new brachiocephalic fistula.

In light of his significant comorbidities and poor functional baseline we decided against a GA, preferring an awake regional anaesthetic technique. We initially planned an infraclavicular brachial plexus block.

In theatre the patient was positioned 30-degree head up in a fully monitored environment, with intravenous access, a 'stop before you block' check and appropriate sterility. The left arm was abducted to facilitate scanning and needling. A high frequency 6-10mHz linear transducer (Sonosite S-nerve II, Sonosite Inc, Bothell, Washington, USA) was placed below the clavicle in a parasagittal plane, medial to the coracoid process. Multiple collateral veins were evident as shown in Figure 1, with the medial cord surrounded. In light of this we also scanned at the level of the supraclavicular and axillary approaches to the brachial plexus. This again revealed multiple venous collaterals at both levels, however there was relative sparing at the axillary level superficial to the axillary artery. Using this knowledge, we decided to proceed with an infraclavicular approach but accepted a high likelihood of poor spread to the medial cord, with the axillary approach providing a rescue option.

A 100mm 21-gauge echogenic needle (SonoPlex II, Pajunk, Germany) was inserted using an in-plane technique, with successful needle tip placement between the axillary artery and posterior cord. Upon injection, LA spread to the posterior cord was satisfactory but limited spread to the medial cord was noted. Subsequent coverage of the lateral cord was achieved but needle advancement over the axillary artery to target the medial cord proved impossible due to obstructing venous collaterals. In total, 25mls of 0.75% ropivacaine was administered.

Early sensory testing 10 minutes post block suggested medial cord sparing. Taking into account the poor medial cord spread seen on US, the need for a successful awake technique and our pre-scan knowledge of the axillary sonoanatomy; an additional block at the axillary level was performed targeting the un-obstructed median, ulnar and medial cutaneous nerve of forearm nerves with a further 10mLs of LA administered.

Sensory and motor testing fifteen minutes later revealed complete anaesthesia of the arm. No rescue analgesia was required during the operation, with the surgery completed uneventfully. Only two doses of 0.5mg of midazolam were administered intraoperatively for anxiolysis. There were no significant post-operative complications with minimal

post-operative pain and complete block resolution at 24 hours.

Discussion

Awake upper limb surgery under regional block is not a new concept, with an increasing prevalence in upper limb orthopaedic lists worldwide, and regular use for fistula creation [1]. Upper limb surgery can be facilitated using general anaesthesia and regional techniques, with both having their advantages and disadvantages. The technique performed largely depends on the planned surgery, the patient's overall health status, their informed choice and the expertise of the anaesthetist. However, in this gentleman's case we were presented with a patient with significant cardiac, respiratory, hepatic and renal co-morbidities, coupled with a very poor functional baseline. The obvious urgency of the surgery, for both fixation of his fracture and creation of a new fistula for crucial haemodialysis meant cancellation or postponement was not an option. We deemed him high risk for a GA, with a significant risk of morbidity and mortality, and an awake technique using a brachial plexus block was the preferred option. Following an informed consent process the patient agreed to this awake regional technique.

Initially we planned an infraclavicular approach, however this was revised following a pre-scan which revealed significant venous collaterals surrounding the brachial plexus at this level (Image 1), potentially limiting needling and LA spread to the medial cord. On subsequent scanning of the axillary approach multiple venous collaterals were again evident, however they were mainly located inferior to the artery and superior to the conjoint tendon surrounding the radial nerve with relative sparing superficial to the artery were the median, ulnar and median cutaneous nerve of forearm nerves were located. Based on this we decided to proceed with an infraclavicular approach but accepted a high likelihood of poor spread to the medial cord. With the prior knowledge of the gentleman's sonoanatomy however, we knew a completion block targeting the branches of the median cord at the axillary level was possible.

The authors accept that during an infraclavicular approach, observed LA spread to the medial cord on US is not always required to result in a successful block of the cord, particularly if high LA volumes are used when injecting posterior to the artery. We commonly preform this approach with only two injection points; one posterior to the artery to target the posterior and medial cord, and one adjacent to the lateral cord. However, if surgical anaesthesia of the arm is required for awake surgery, we would commonly preform a third injection targeting the medial cord if poor medial LA spread is noted on US following the posterior injection. Indeed, studies have revealed multiple septae at the infraclavicular level which can potentially limit LA spread with single injection techniques [2,3]. Early sensory testing in this gentleman's case also suggested medial cord sparing, an assessment for the loss of pin prick sensation revealed sparing in the cutaneous distribution of the ulnar nerve and medial cutaneous nerve of forearm. As we didn't have an acceptable Plan B if our regional technique failed, we quickly moved to perform a completion block at the axillary level.

We note the case report by Beh et al discussing multiple venous collaterals preventing a supraclavicular approach to the brachial plexus. They described using a costoclavicular approach to perform awake revision vascular access surgery [4]. We believe our case is unique due to the planned multi-level approach to the brachial plexus, safely targeting different sections of the plexus in the setting of grossly abnormal venous anatomy. The case also highlights poor medial cord spread following a high-volume injection posterior to the artery, however in this case this poor spread may Have been due to multiple venous collaterals as opposed to septae (2,3].

The presence of large chronic collateral veins following AV fistula creation can occur, resulting in substantial arm lymphoedema, and potentially leading to future fistula failures [5,6]. In retrospect this gentleman's arm did have features of lymphoedema, heralding this issue. Although not ideal, in some cases transecting a small vein during a regional technique may be necessary to ensure appropriate needle tip position and LA spread, with appropriate compression applied afterwards. In this gentleman's case however this was undesirable, as although we were not needling near the AV fistula itself, as mature flow rates can reach 600-1200mLs/minute, even a small proportion of this blood flow through these large collaterals veins could result in significant bleeding and haematoma if venous puncture occurred [7].

This complex case also highlights the importance of advanced training in regional anaesthesia. We note and fully agree with the recent editorial by Turbitt et al discussing the future direction of regional anaesthesia [6]. They discuss cementing it as a core component of perioperative care for all anaesthetists through the widespread implantation of a small number of high value blocks for the many. The article however also suggested the ongoing need for experienced regional anaesthetists, so when significant challenges present themselves, as in this case, appropriate expertise is available. Identification of this gentleman's unusual sonoanatomy, with consideration of a multi-level approach to the brachial plexus required applied knowledge of the cutaneous, osseous and myotomal innervation of the upper arm to adequately anaesthetise each segment required. This skill set of applied anatomy coupled with functional sonoanatomy is required when challenging cases arise, especially in high risk patients were avoiding a general anaesthetic is necessary. The knowledge and confidence to perform both the infraclavicular and axillary approaches, whilst limiting the LA dose delivered to ensure maximal doses were not exceeded is in line with the

guidelines for fellowship training in regional anaesthesiology set out by the Regional Anaesthesiology and Acute Pain Medicine Fellowship Directors Group [8].

In conclusion, this was a challenging case of an ASA 4 patient with multiple co-morbidities who benefited from successful awake surgery using a multi-level brachial plexus approach, to allow safe needling and LA spread to all aspects of the plexus despite multiple large obstructing venous collaterals. Thorough pre-scanning at different levels of the brachial plexus, coupled with sound anatomical knowledge was essential to ensure total surgical anaesthesia of the arm and successful awake surgery.

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Conflict of Interest

The authors have no conflict of interest to declare. No external funding was received for writing this article.

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