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Axillary Plexus Block: Paresthetic or Perivascular

In this issue of Anesthesiology, Partridge *et al.*[1] present an interesting study on the functional anatomy of the brachial plexus sheath and its implications for anesthesia. To correctly understand the importance of their results and conclusions regarding the technique for axillary plexus blocks, it is necessary to briefly review the evolution of this blockade.

Several modifications of the technique for axillary plexus blockade have been proposed since it was introduced by Hirschel[2] in 1911. Although simple and with fewer complications than the supraclavicular technique, the axillary block did not become popular until its reintroduction by Burnham[3] in 1959. He described how the major brachial nerves were arranged around the axillary artery and how this neurovascular bundle was surrounded by "a sturdy fascia." Blockade of these nerves could be achieved by "bathing" them in a local anesthetic solution, and the landmarks for injection were the arterial pulse and the "pop" as the needle pierced the neurovascular fascia. Burnham injected only 16 ml of local anesthetic (8 ml on each side of the artery) in the average adult, but, in 42 cases, reported complete anesthesia with this volume. Based on dissections of seven cadavers, de Jong[4] calculated that 40–50 ml must be injected into the axillary neurovascular sheath (NVS) in the adult to obtain a sufficient "bath" of all major nerves, including the musculocutaneous, before it disappears into the coracobrachial muscle high up in the axilla. De Jong described the axillary neurovascular sheath, which surrounds the neurovascular bundle, as a "sturdy tube of deep fascia derived from the cervical prevertebral fascia," and that "thin areolar septa within the sheath support the individual nerves and vessels." Still, de Jong recommended one injection on each side of the artery, preferably after eliciting paresthesia or the aspiration of blood to verify a correct needle position.

The perivascular arrangement of the axillary plexus within a fascial tube was the basis for the single injection techniques later described by Eriksson[5] and Winnie[6,7]. Winnie suggested blocking the brachial plexus at various levels along the NVS by merely injecting the local anesthetic at a suitable level through a single centrally directed "immobile" needle. In 1977, Selander[8] presented the use of a 4–5 cm long catheter-over-the-needle that could be introduced into the NVS without searching for paresthesia. This flexible catheter could then be left for longer periods, allowing the block to be prolonged without further needling.

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Thus far, the perivascular arrangement of the axillary plexus within a functionally single compartment, surrounded by a tube-like sheath, was widely accepted. In spite of this theoretically convenient construction, there were sometimes problems with patchy anesthesia, especially due to insufficient block of the radial or musculocutaneous nerves.

In an effort to explain such incomplete blocks, Thompson and Rorie[9] presented a new concept of the functional anatomy of the brachial plexus sheaths. They stated that the axillary NVS is a multicompartmented structure formed by septa which extend inward from the sheath, and fascial compartments were described for each nerve. The authors concluded that these septa limit the circumferential spread of the local anesthetic, thus making the single injection technique illogical and of no value. These statements were based on dissections of three cadavers and ten CT-scans performed after injection of varying volumes of a local anesthetic-contrast mixture into the NVS with three various techniques. Thompson* later stated that "in reality, successful axillary block depends upon a technique of multiple small volume injections into multiple compartments, not upon a single large volume injection into a single compartment." He also declared that "the obtaining of paresthesia does not guarantee a successful block," but recommended that "if paresthesias are obtained, stop and inject only 3–5 ml of solution before moving on." All together, 20–30 ml of local anesthetic should be enough. As yet, no clinical study has been presented confirming Thompson's recommendations.

A certain degree of confusion now spread among anesthesiologists. How should the axillary block be performed? The idea of multiple injections of small volumes, perhaps after eliciting paresthesias from as many nerves as possible, was certainly tempting to many. Against it were the studies by Selander *et al.*[10] and Plevak *et al.*,[11] which indicate that the paresthesia technique for axillary block increases the incidence of postanesthetic neuropathy. Furthermore, the concept of multiple paresthetic injections is inconsistent with a success rate of at least 80% with a single injection and/or non-paresthesia technique (table 1).

What, then, about the problem of poor predictability of block of the musculocutaneous, and, to some extent, the radial nerves?

A rational explanation was presented by Vester-Andersen *et al.*,[13] who studied the spread of dyed gelatine injected into the axillary neurovascular sheath of 20 cadavers. Fifty milliliters was injected through a catheter directed proximally, inserted just distal to the major pectoral muscle, with the arm abducted 90°. As soon as the solution had coagulated, the axilla was carefully dissected. The gelatine spread proximally to at least the coracoid process, and, in all cases, the neurovascular bundle was located in the lateral part of the gelatine cast. The median and ulnar nerves were all surrounded or in good contact with the gelatine, while only 75% of the radial and 70% of the musculocutaneous nerves were judged to be in sufficient contact with the injectate. No septa were found to separate the nerves and the blood vessels. Based on these results, the authors suggested a modification of the block technique: the perivascular injection should be made with the patient's arm by his side to attain a more even spread within a relaxed neurovascular bundle. However, such injections can only be made using a catheter technique.

TABLE 1. Success Rates of Axillary Blocks Performed with a Single-Injection and/or Non-paresthesia Technique

Reference	No. of Cases	% Success
Bosomworth *et al.*, 1961[14]	224	89, 6
Brand & Papper, 1961[15]	246	91, 5
Hamelberg *et al.*, 1962[16]	208	81
Hollmen, 1966[17]	40	87, 6
Hudon & Jaques, 1959[18]	165	86
Leahy *et al.*, 1964[19]	206	80
Moir, 1962[20]	140	87, 9
Plevak *et al.*, 1983[11]	239	85
Selander, 1977[8]	137	80
Spillar & Spillar, 1962[21]	198	89
Vester-Andersen *et al.*, 1984[22–24]	240	88, 3
Wu, 1971[25]	30	96, 7
Total	2173	86, 9

Interestingly, Partridge *et al.* originally questioned the idea of a single-compartmented NVS. They undertook their study primarily to confirm the observations of Thompson and Rorie regarding the presence of septa and to determine to what degree such septa form a barrier for the spread of the local anesthetic. The axillae and neurovascular bundles of 18 cadavers and one stillborn fetus were examined, both by dissection and after injection of 20–30 ml of methylene blue or Latex solutions. They found the axillary sheath to be made up of numerous thin layers of velamentous fascia with no free space between layers. The injected solution easily dissected its way within the loose perivascular connective tissue and immediately reached the median, ulnar, and radial nerves, although the musculocutaneous nerve is not mentioned. Thus, the septa of Thompson and Rorie (in fact, observed earlier by de Jong) do exist, but the injection tests showed them to be functionally incomplete and easily deranged. Although only 20–30 ml was injected, a common perivascular space was formed which included the three large terminal nerves of the axillary plexus. These results at large agree with those of Vester-Andersen *et al.*[12]

* Thompson GE: Upper extremity nerve block. Am Soc Reg Anesth, Refresher Course, San Antonio, 1986.

Thus, the neurovascular axillary sheath may be considered a potential perivascular space, which is easily opened up to a real space through an injection close to the artery. Such periarterial sheaths seem to be common: according to Gray's Anatomy,[13] "the arteries . . . are enclosed in thin fibroareolar sheaths . . . and the sheath usually encloses the accompanying veins and sometimes a nerve." It is, of course, fortunate that the distal part of the brachial plexus is grouped around the axillary artery, since this arrangement is a prerequisite for the single-injection perivascular technique of the axillary plexus block. The study by Partridge *et al.* is an important contribution to regional anesthesia, since it sheds light on the question of the perivascular septa of the axillary sheath: these do exist, but seem to be functionally unimportant. Patchy anesthesia may be explained by individual irregularities of the neurovascular sheath and/or an uneven distribution of the injected local anesthetic, perhaps due to an insufficient volume or unsuitable position of the arm during injection.

The conclusion of Partridge *et al.*, with which I agree, is that there is a functional basis for the single-injection technique, but that, in experienced hands, any technique may result in a satisfactory axillary block. However, in order to avoid post-anesthetic neuropathy, paresthesia techniques should not be used. Any technique which results in a good block without injury to the patient is a good technique. Therefore, my answer to the opening question is: use a perivascular technique, preferably with a catheter or a short-bevel needle, and try to avoid paresthesias.

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