BJA

British Journal of Anaesthesia, 116 (5): 610–7 (2016)

doi: 10.1093/bja/aew097
Review Article

Ultrasound-guided radial artery cannulation in adult and paediatric populations: a systematic review and meta-analysis

Leigh White[1,2,*], Alice Halpin[2], Marianne Turner[2] and Laurent Wallace[3]

[1]School of Medicine, Faculty of Science, Medicine and Health, University of Wollongong, Wollongong, NSW 2522, Australia, [2]Wagga Wagga Base Hospital, Wagga Wagga, NSW, Australia, and [3]Campbelltown Hospital, Campbelltown, NSW, Australia

*Corresponding author. E-mail: lw844@uowmail.edu.au

Abstract

Background: Ultrasound is a well-validated adjunct to central venous cannulation; however, previous reviews of ultrasound-guided radial artery cannulation have been inconclusive. The aim of this study was to assess the use of ultrasound in radial artery cannulation in adult and paediatric populations.

Methods: A systematic search of five major databases for all relevant articles published until November 2015 was conducted. Randomized controlled trials of radial artery cannulation with and without ultrasound guidance were included. All studies were assessed for level of evidence and risk of bias. Studies were grouped in adult and paediatric populations for each outcome. A meta-analysis was performed to analyse the data.

Results: Eleven randomized controlled trials (six adult and five paediatric) were found. In both the adult and paediatric populations, there was high-level evidence for significantly improved first-attempt success rate and number of attempts with the use of ultrasound guidance.

Conclusions: This is the first level one systematic review to demonstrate strong evidence for the use of ultrasound guidance in radial artery cannulation in adult and paediatric populations. In the adult population, ultrasound use significantly increased first-attempt success rate, which subsequently resulted in a significant reduction in the number of attempts. The benefits of ultrasound were also shown in the paediatric population, with a significant increase in first-attempt success rate and reduction in the number of attempts. The use of ultrasound as an adjunct to radial arterial cannulation should now be considered best practice.

Key words: ultrasound; radial artery; catheterization; cannulation

Arterial cannulation is a common and important procedure performed to allow repeated arterial blood sampling and continuous blood pressure monitoring.[1–3] The most common site for arterial cannulation is the radial artery, because of the dual arterial supply to the hand, its superficial location, and the relatively low rate of complications.[1] Traditionally, radial artery cannulation has been performed with the aid of pulse palpation and anatomical knowledge.[2]

This invasive procedure is generally safe, but in 1% of patients there are thrombotic, mechanical, or infectious complications.[2–4] The risk of a complication increases with each additional attempt.[4] With each failed cannulation attempt, the procedure becomes increasingly difficult because of vasospasm and haematoma formation causing a weak or even absent pulse.[2] Factors associated with failed radial artery cannulation include obesity, hypotension, oedema, atherosclerosis, and arterial

scarring.[1 2] There is also an increased risk of failed cannulation in small children because of the greater proportion of subcutaneous fat and smaller arterial diameter.[4–7]

In an attempt to reduce cannulation failure rates and associated morbidity, the use of ultrasound guidance has grown significantly in popularity.[2 6] The use of ultrasound guidance is a well-validated adjunct for central venous cannulation.[3 6 8] Theoretically, ultrasound guidance provides the ability to overcome the majority of factors associated with cannulation failure. The most recent systematic review and meta-analysis by Gu and colleagues[8] yielded limited results on this topic. A key limitation in previous reviews is the lack of homogeneity between studies, with adult and paediatric data analysed together.[8] There has also been a lack of large high-quality randomized controlled studies to support the use of ultrasound conclusively as a best practice adjunct to radial artery cannulation. Since the most recent systematic reviews and meta-analyses by Shiloh and colleagues[9] and Gu and colleagues,[8] a number of large studies have been released.[1 5 6 10–12] The aim of this systematic review was to compare the traditional palpation technique with ultrasound guidance in the performance of radial artery cannulation of adult and paediatric populations.

Methods

Search strategy

A systematic search of five databases (CINAHL, SCOPUS, PubMed, Medline, and Web of Science) was conducted from the inception of the databases until November 2015. This search was conducted systematically by two independent reviewers searching the following terms: (1) (radial artery) AND (ultrasound) AND (cannulation); and (2) (radial arterial) AND (catheterization) AND (ultrasound). For completeness, a manual reference check of recent reviews and other accepted papers was performed to identify any additional studies.

Inclusion and exclusion criteria

For a study to be included, the study needed to be a randomized controlled trial (RCT) reporting on ultrasound-guided radial artery cannulation (no systematic reviews or meta-analyses). Two reviewers (L. White and A.H.) independently assessed and agreed upon each study for inclusion in this systematic review. Studies investigating the use of radial artery cannulation for the purpose of cardiac catheterization were excluded.

Data extraction

Two reviewers (L. White and A.H.) independently extracted data from each article that met the inclusion criteria. The studies were separated into two groups, those investigating adult and those investigating paediatric populations. The data extracted from each study included the mean age of the study population, indication for arterial cannulation, operator, and clinical outcomes. The data collected by each reviewer were then compared for homogeneity.

Level of evidence, risk of bias, and outcome level of evidence ranking

Each article was evaluated using the Centre for Evidence-Based Medicine (CEBM) levels of evidence introduction document.[13] These studies were then assessed for risk of bias and methodological quality using the Cochrane Collaboration's tool for assessing the risk of bias.[14] The results from each study were then grouped into individual outcomes. These outcomes were each given a level of evidence ranking based on the collective strength of evidence, as follows.[15]

1. High-level evidence: two or more high-quality (quality score ≥4) RCTs with ≥75% consistency in findings.
2. Moderate-level evidence: one high-quality RCT and two or more low-quality studies with ≥75% consistency in findings.
3. Limited evidence: one high-quality RCT or multiple low-quality studies with ≥75% consistency in findings.
4. Conflicting evidence: multiple low- or high-quality studies, or both with ≤75% consistency in findings.
5. No evidence: no studies could be found; may include technique reports.

Statistical analyses

The combined data were analysed using RevMan 5.3 software (The Nordic Cochrane Centre, Copenhagen, Denmark). Differences were expressed as relative risk (RR) with 95% confidence interval (CI) for dichotomous outcomes, and the weighted mean difference (WMD) with 95% CI for continuous outcomes. The Mantel–Haenszel (M-H) random effects model was used. Heterogeneity was assessed using the I^2 statistic, with an I^2>50% indicating significant heterogeneity. A P-value of <0.05 provided evidence of significant RR and WMD. A P-value of <0.10 was used to demonstrate heterogeneity of intervention effects.

Results

Literature search results

The initial systematic literature search yielded 954 citations, of which 34 were retrieved for review. These articles were selected for retrieval based on a review of the abstract, which appeared to meet the search criteria. Of these 34 articles, 11 met the inclusion criteria (Fig. 1). These included six adult (Table 1) and five paediatric RCTs (Table 2).

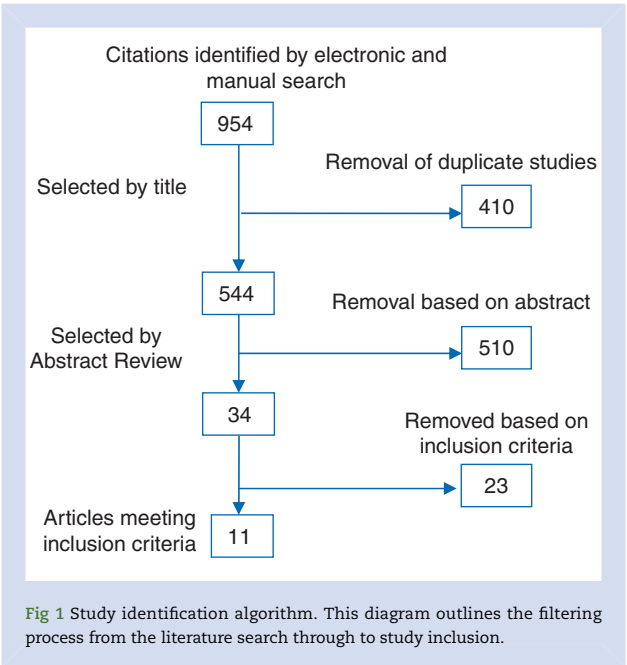

Fig 1 Study identification algorithm. This diagram outlines the filtering process from the literature search through to study inclusion.