Original Contribution

Optimal wrist positioning for radial arterial cannulation in adults: A systematic review and meta-analysis

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ARTICLE INFO

ABSTRACT

Background: Wrist extension is commonly taught as part of the radial artery cannulation technique. Currently the degree of wrist extension required to optimize cannulation success remains inconclusive. This is the first meta-analysis to investigate optimal wrist positioning for radial artery cannulation.
Methods: Five major databases (CINAHL, SCOPUS, PubMed, Medline and Web of Science) were systematically searched until June 2016. All studies were assessed for level of evidence and risk of bias. The data for each outcome was then assessed via a meta-analysis.
Results: Five studies including 500 patients were found. There is moderate evidence to support 45° wrist angulation for improved radial artery cannulation. Radial arterial height is likely to be increased at 45°, cannulation time is significantly faster and success rates are likely higher than at other degrees of angulation. However, this evidence is confounded by the significant heterogeneity (I^2 >75%) which is at least in part related to a high proportion of healthy young volunteers who were amongst the studied populations.
Conclusion: This review found moderate evidence in support of a 45° wrist angulation to facilitate arterial cannulation, however the results are largely limited by the external validity of the data collected given the restrictive populations studied. Any further studies investigating the effect of altering wrist angulation on radial artery cannulation should focus on populations who are either likely to require arterial cannulation or predisposed to difficult access.

1. Introduction

The most common location for invasive blood pressure monitoring and arterial blood sampling in the critical care setting is the radial artery [1]. Radial artery cannulation is generally safe procedure, however a small percentage of patients experience infectious, thrombotic or mechanical complications and the incidence of these complications increases with each additional attempt [2]. The use of ultrasound has recently been shown to be a best practice as an adjunct to radial artery cannulation [3]. This translates into a significantly improved first attempt success rate and a reduction in the mean number of attempts required.

Current studies show that on average between one and three attempts using ultrasound guidance are required for successful cannulation [3]. With this in mind there have been a number of studies investigating other aspects of the radial artery cannulation process. A recent meta-analysis by Gao and colleagues showed no evidence to support either the long-axis in-plane or short-axis out-of-plane techniques [4]. Another aspect that may influence first attempt success

rate of radial artery cannulation is the angle at which the wrist is bent during the procedure.

A commonly cited cause of failure to cannulate under ultrasound guidance is small radial artery diameter [5]. Several studies have been performed investigating the effect of wrist angle on radial artery size and ultimately first pass success. Currently, there are no meta-analyses providing a concise summary of this growing body of literature. The aim of this review is to determine whether there is an optimum wrist angle for radial artery cannulation as determined by radial artery measurements and cannulation success.

2. Methods

2.1. Search strategy

Five databases (CINAHL, SCOPUS, PubMed, Medline and Web of Science) were independently searched from their inception until June 2016. This systematic search was conducted independently by TM and LW. The search terms included:

(1) (radial (artery OR arterial)) AND (wrist (angle OR angulation OR position OR positioning));

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A manual reference and citation check of all papers and recent reviews was performed to identify any additional studies.

2.2. Inclusion and exclusion criteria

For inclusion into this review, all studies were required to report on measurements of the radial artery and/or successful radial artery cannulation. These outcome had to be measured secondary to differing wrist angles.

Two reviewers (TM and LW) independently assessed and agreed upon each study for inclusion in this systematic review.

We only included papers assessing adults, as pediatric radial artery anatomy differs substantially. We excluded any papers performing arterial punctures anywhere other than within 15 cm of the wrist, this approximates to the lower half of the forearm.

2.3. Data extraction

TM and LW independently extracted data from each of the included articles. The data extracted from each study included the study population demographics and co-morbidities, wrist angles, radial artery measurements and/or direct effect on radial artery cannulation. All data collected was then compared for homogeneity.

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

Each articles level of evidence was evaluated using the Centre for Evidence Based Medicine (CEBM): Levels of Evidence [6]. These studies were then assessed for risk of bias and methodological quality using the Cochrane Collaboration's tool for assessing the risk of bias [7]. As dictated by the risk of bias, or other serious methodological flaws, Level of Evidence may then be downgraded as described in the Cochrane tool.

The results from each study were then grouped into individual outcomes.

2.5. Statistical analyses

RevMan 5.3 software was used to perform the data analysis (The Nordic Cochrane Centre, Copenhagen, Denmark). Differences in dichotomous outcomes were expressed as relative risk (RR), and continuous outcomes as a weighted mean difference (WMD), both with a 95% confidence interval (CI). The Mantel–Haenszel (M-H) random effects model was applied to the analysis. The I^2 statistic was used to assess heterogeneity, with an $I^2 > 50\%$ indicating significance. A significant RR and WMD was defined as a p value <.05. Unless otherwise stated our in-text results are presented as either "[Mean Difference, 95% Confidence Interval, P value]" or "Mean Difference [95% CI, P value]".

3. Results

3.1. Literature search results

The systematic literature search yielded 235 citations, of which 36 were retrieved for review. These articles were selected for retrieval based on a review of their abstract, which appeared to meet the search criteria. Of these 36 articles, 6 met the inclusion criteria (Fig. 1). Notably, the paper by Mizukoshi et al [8], whilst eligible for inclusion could not be compiled into our meta-analysis as the data was only presented graphically without necessary numerical data. The authors were contacted for unpublished data to no success. The five remaining studies included 500 patients (Table). Each study was then screened for risk of bias and methodological quality using the Cochrane Collaboration's tool for assessing the risk of bias (Fig. 2). Of these five studies, two were high quality level one RCTs and three high quality, level one crossover studies (Table). Whilst crossover studies are not explicitly mentioned by the CEBM grading system we use, they fall under the level one 'n-of-1' banner and the inclusion of them as level one evidence is consistent with other groups' recommendations [9].
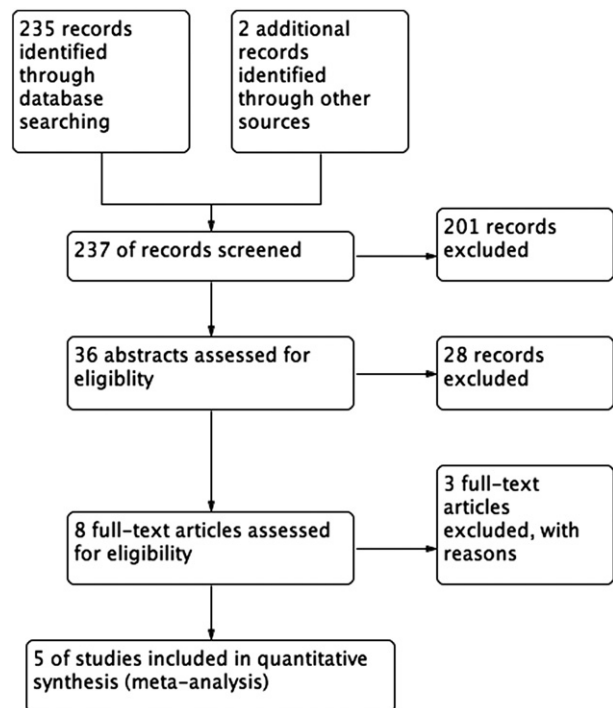

Fig. 1. Study identification algorithm outlining the filtering process from the literature search through to study inclusion.

4. Ultrasound measurement of the radial artery

4.1. Radial arterial height on ultrasound examination

There was conflicting evidence on the affect of wrist extension on RA height. Five level one papers assessed this outcome (Fig. 3). At 15° extension there was no significant effect of extension of RA size, with all three papers describing minimal non-significant effects. At 30° there was a borderline-significant increase in arterial height, with a mean difference 0.14 mm [0.00–0.29, P = .05]. One paper found reported a significant increase in the arterial height, one paper found a non-significant increase and the final paper found no effect. There was substantial heterogeneity, $I^2 = 70\%$.

At 45° there was incongruence between findings. Four papers reported this outcome, with two finding significant and large effect sizes, whilst two further papers reported no effect and a small, significant negative effect. Overall this angle on extension had the largest mean difference+ 0.30 mm, but was not statistically significant [−0.20 to 0.79, P = .24]. The data's heterogeneity was very high, $I^2 = 99\%$. Wrist extension beyond 60° found no significant change in RA height on ultrasound. Four papers assessed 60° extension, with two finding a small, positive significant effect, one paper finding no effect, and one reporting a small reduction in arterial height. Only two papers report on extension to 70–75°, with one paper finding a small significant effect and the other reporting no effect.

4.2. Sensitivity analysis results by age and by participant status

We undertook a sensitivity analyses of the data to re-examine difference in the studies populations. As 45° was the most heterogonous set of data, and examined by the most groups we present that information here. We re-analyzed the data based on participant age (Fig. A1) and participant type (hospital inpatient vs healthy volunteer) (Fig. A2).

There was a significant difference in the overall effect sizes observed base on the age of participants; in subjects less than 60 years old [0.11 mm, −0.35-0.57, P = .64] as opposed to those older [0.72 mm, 0.23–1.21, P = .004].