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Original Contribution

Effects of long axis in-plane vs short axis out-of-plane techniques during ultrasound-guided vascular access☆,☆☆

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ABSTRACT

Background: Currently, whether long-axis in-plane (LA-IP) is superior to short-axis out-of-plane (SA-OOP) during ultrasound-guided vascular access remains inconclusive. We, therefore, conducted a meta-analysis of randomized controlled trials to compare the effects of LA-IP vs SA-OOP techniques in patients undergoing ultrasound-guided vascular access (USGVA).

Methods: A computer-based literature search of PubMed, Embase, and the Cochrane Library (up to October 2015) was performed to identify randomized controlled trials that evaluated the effects of LA-IP compared with SA-OOP in patients undergoing USGVA. The primary end point was the first-pass success rate. Secondary end points included mean time to success, mean attempts to success, and incidence of the complication of hematoma. Weighted mean differences (WMDs) and relative risks (RRs) with 95% confidence intervals (CIs) were calculated by random-effects model.

Results: Five eligible studies with a total of 470 patients satisfied the inclusion criteria. There was no significant difference for the first-pass success rate (RR, 1.06; 95% CI, 0.91-1.23; $P = .44$), mean time to success (WMD, 4.78 seconds; 95% CI, −4.43 to 13.99; $P = .31$), mean attempts to success (WMD, 0.06 times; 95% CI, −0.23 to 0.35; $P = .69$), and incidence of the complication of hematoma (RR, 2.86; 95% CI, 0.32-25.42; $P = .35$) between the LA-IP and SA-OOP groups.

Conclusions: There is insufficient evidence to definitively choose either LA-IP or SA-OOP in patients undergoing USGVA. Further robustly well-designed trials are warranted to investigate the appropriate technique in patients receiving USGVA.

1. Introduction

Vascular cannulation as a common invasive procedure is often required in most of clinical settings, particularly in emergency department (ED), intensive care unit, and operating room. In general, vascular cannulation includes catheterization of vein and artery, which is commonly used as an important aspect of patient care for the administration of fluids and medications [1]. Importantly, it allows continuous monitoring purposes, such as central venous pressure detection, arterial blood gas analysis, and other tests of blood indicators. Nowadays, the latest guidelines stated that the routine use of ultrasound guidance is recommended for vascular cannulation, especially for internal jugular vein cannulation, radial artery catheterization, and percutaneous intravenous central catheterization [1]. In addition, numerous studies have shown that ultrasound-guided vascular access (USGVA) can improve the first-pass success rate; reduced number of needle passes and complication incidence; and shorten access time for radial artery catheterization [2,3], peripheral intravenous access [4], and nerve block [5,6].

There are 2 basic approaches for USGVA techniques, that is, long-axis in-plane (LA-IP) and short-axis out-of-plane (SA-OOP) [1]. Using an inanimate model, Blaivas et al [7] found that SA approach represented faster than LA approach in terms of vascular access time and LA approach was associated with improved visibility of the needle tip during vessel puncture [8]. Unluckily, it is currently unknown which puncture technique provides the optimal conditions for USGVA. Several randomized controlled trials (RCTs) were designed to compare the effects of 2 different needling techniques in success rate at the first attempt, catheter insertion time, and number of needle sticks in patients undergoing USGVA [9–13]. However, these studies not only had wide variation in

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sample size but also conveyed inconclusive results. We, therefore, conducted a meta-analysis involving available RCTs to compare the effects of 2 different needling approaches in patients undergoing USGVA.

2. Methods

2.1. Data sources and literature search

Computer-based literature search was performed on PubMed, Embase, and the Cochrane Library from inception through October 2015 for eligible trials with using the following keywords: ("long axis" OR "in plane") and ("short axis" OR "out of plane") and "ultrasound." Eligible trials limited by RCT and written in English were included. In addition, bibliographies of all potential studies, including reference lists, citation searches, the latest guidelines, and relevant systematic reviews, were manually searched.

2.2. Study selection

The following selection criteria were included: (1) population: either adult or pediatric patients undergoing USGVA; (2) intervention vs control: LA-IP vs SA-OOP; (3) outcome measures: the primary end point was the first-pass success rate, and secondary end points included mean time to success and mean attempts to success; and (4) study design: RCT.

2.3. Data extraction and outcome measurement

All data were extracted by 2 independent investigators (YBG and JHY). In detail, the data included first author, publication year, country, study design/Jadad score, number of patients (LA-IP/SA-OOP), weight (LA-IP/SA-OOP), clinical setting, vessel type, ultrasound device, ultrasound type, catheters, operator experience, and results. Disagreements among authors were settled by discussion or a third investigator (JMM). Predefined primary end point was the first-pass success rate, and secondary endpoints included mean time to success (defined as the time period between penetration of skin and aspiration of venous blood into the catheter) and mean attempts to success (defined as the number of times the needle was withdrawn and redirected).

2.4. Quality and risk-of-bias assessment

The quality of RCTs was evaluated according to the Jadad scale [14]. In detail, randomization (0-2 points), blinding (0-2 points), and the dropouts and withdrawals (0-1 points) were defined in the scale. A score of less than or equal to 2 indicates low quality, whereas a score of greater than or equal to 3 indicates high quality [15]. In addition, the risk of bias was assessed by the Cochrane risk-of-bias tool [16].

2.5. Statistical analysis

The present study was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement [17]. Weighted mean differences (WMDs) for continuous outcomes with 95% confidence intervals (CIs) and relative risks (RRs) for dichotomous outcomes with 95% CIs were calculated by random-effects model [18]. The heterogeneity across studies was tested using the I^2 statistic, and the I^2 greater than 50% indicated significant heterogeneity [19]. If so, we would use sensitivity analyses conducted by sequentially excluding each study to identify the potential sources of heterogeneity and investigate the influence of a single study on the overall pooled estimate. Importantly, to check the influence of various factors on the first-pass success rate, we further performed subgroup analyses based on differently clinical setting among studies, such as ultrasound type (Doppler ultrasound vs real-time 2-dimensional [2D] ultrasound), vessel type (the radial artery vs the right internal jugular vein), and sample size (≥99 vs <99). Furthermore, publication bias was not assessed because only 5 RCTs (<10) were included in the present study. All meta-analyses were performed using RevMan 5.3 (The Cochrane Collaboration, Oxford, UK). A 2-sided P value of less than .05 indicated statistical significance.

3. Results

3.1. Eligible studies and studies of characteristics

A total of 235 relevant articles were identified from the initial search. After reviewing the titles and abstracts and removing duplicates, 212 were excluded for various reasons, and finally, 5 eligible RCTs [9–13] involving a total of 470 patients were identified for our meta-analysis (Fig. 1). Next, the main characteristics of the available 5 RCTs are shown in Table 1. In detail, all the 5 RCTs were published in English and involved adult patients. They were published from 2011 to 2014, and the sample sizes of them ranged from 40 to 163. Five RCTs were conducted in 5 different countries including Turkey [9], Ireland [10], the United States [11], China [12], and Egypt [13]. Among the included trials, Doppler ultrasound was applied in 3 RCTs [9,11,12], whereas real-time 2D ultrasound in 2 RCTs [10,13]. With respect to vessel type,

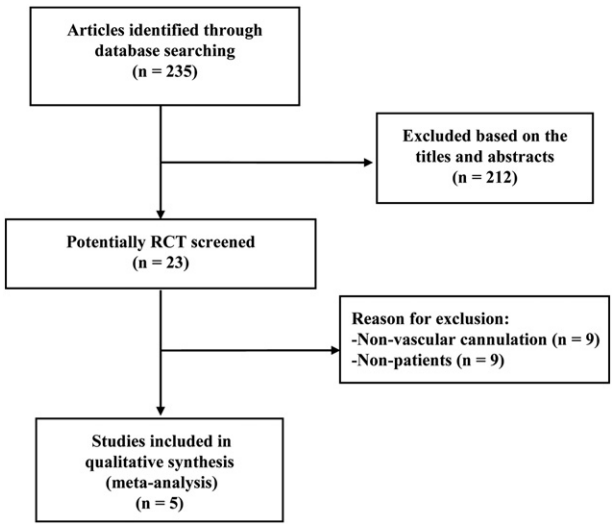

Fig. 1. Search strategy and flow chart of the meta-analysis.