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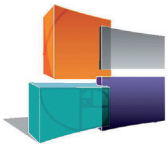

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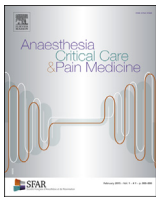

Recommendations

Guidelines on the use of ultrasound guidance for vascular access

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A B S T R A C T

Insertion of vascular access is a common procedure with potential for iatrogenic events, some of which can be serious. The spread of ultrasound scanners in operating rooms, intensive care units and emergency departments has made ultrasound-guided catheterisation possible. The first guidelines were published a decade ago but are not always followed in France. The French Society of Anaesthesia and Intensive Care has decided to adopt a position on this issue through its Guidelines Committee in order to propose a limited number of simple guidelines. The method used was the GRADE® method using the most recently published meta-analyses as the source of references. The level of evidence found ranged from low to high and all the positive aspects associated with ultrasound guidance, i.e. fewer traumatic complications at puncture, probably or definitely outweigh the potential adverse consequences regardless of whether an adult or child is involved and regardless of the site of insertion.

1. Steering committee

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2. Introduction

2.1. Context of the guidelines

2.1.1. Background

Insertion of a central venous access, whether it is being used for a short or a long period of time, is a common procedure, which is often undertaken by intensivists and anaesthetists. The associated morbidities include punctured arteries for almost 10% of cases and haemothorax or pneumothorax for about 3% [1]. These complications can be serious or even fatal [2]. Although insertion of radial arterial and peripheral venous accesses is not associated with the same iatrogenic risks, it can cause pain and discomfort, delay care and, in the event of failure, deprive the patient of the best possible chances.

2.1.2. Rationale for these guidelines

The first guidelines from the National Institute for Clinical Excellence [3] to recommend the systematic use of ultrasound guidance for puncture when inserting central venous access appeared in 2002, but only 25% of anaesthetists in the English-speaking world seem to follow them [4]. Recently, American and international guidelines were published [5,6]. Although the former recommend a different method to that recommended by the French Society of Anaesthesia and Intensive Care (*Société française d'anesthésie et de réanimation* [Sfar]), the latter – although comprehensive – do not provide explicit, transparent justifications for their proposed guidelines. In addition, one of the main obstacles

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to practitioners accepting international guidelines is unfamiliarity with the latter and inability to understand texts written in a foreign language [7]. For that reason the Board of the French Society of Anaesthesia and Intensive Care has decided to take a position on the subject by convening the Clinical Guidelines Committee to compile a limited set of simple guidelines in French accessible to all practitioners.

2.1.3. Aims of these guidelines

The aim of these guidelines is to issue recommendations on the use of ultrasound guidance for inserting venous and arterial access, whether it is being used for a short- or a long-term duration in both adults and children. Pre-procedural ultrasound assessment only used to mark the skin for subsequent cannulation and Doppler ultrasonography are not addressed because these techniques are less efficient [6].

2.1.4. Literature search and selection criteria

Meta-analyses by Wu et al. [1], Gu et al. [8] and Liu et al. [9] were used as the source of references. Only randomized, controlled trials with a Jadad score [10] of at least 2 were included. The studies by Bobbia et al. [11], Hansen et al. [12], Iwashima et al. [13] and Eldabaa et al. [14] were added to complete the analysis. No relevant published work addressing patients' values and preferences in relation to the subject of these expert guidelines was found. The question of using ultrasound guidance for the femoral artery in adults and children was not addressed because of the absence of any published material.

2.1.5. Population and comparisons

The populations of adults and children were studied separately, comparing the technique of ultrasound-guided catheterization with either anatomical cutaneous landmark-based cannulation or palpation (depending on the insertion site: Internal Jugular Vein, Subclavian Vein, Femoral Vein, Radial Artery and peripheral veins in which insertion is deemed difficult).

2.1.6. Criteria

For central vascular access, the main criteria selected by the experts were: failed puncture, arterial puncture, pneumothorax and haemothorax, as applicable. For other types of vascular access, only success rate was considered. Insertion time was not studied since widely disparate definitions are used. Risk reduction and heterogeneity calculations were redone using Revman® software and evidence profiles were compiled using GRADEpro® software (see Further Materials).

2.1.7. Medico-economic analysis

The medico-economic analysis was carried out by Calvert et al. [15] in 2003 for the National Health Service by analytical decision modelling. The marginal cost of ultrasound guidance for inserting a central venous access is less than 12 €. The scenario is based on a rate of at least 15 procedures a week. The economic analysis shows a saving of over 2000 € per 1000 procedures, based on purchasing and maintenance costs, resources consumed, single-use devices and training costs. However, these results are highly dependent on the number of procedures performed.

2.1.8. Clinical practice guidelines

For most of the vascular approaches investigated, the guidelines below show that ultrasound guidance is superior to traditional anatomical cutaneous landmark-based cannulation techniques. The experts are aware that, in all establishments where vascular approaches (central, peripheral and arterial) are carried out, the availability of ultrasound equipment is still restricted. The experts are also aware that practitioners involved in performing such procedures are not all fully trained in the techniques of ultrasound-guided puncture. This is why these expert guidelines are expected to serve as a foundation for establishing a training programme and to provide a framework for the acquisition of suitable equipment (ultrasound scanners and accessories).

2.2. The GRADE® method

The working method used to compile these guidelines was the GRADE® method. After a quantitative analysis of the literature, this method determines evidence levels separately and therefore assesses the confidence that can be placed in the quantitative analysis and a level of recommendation. The quality of evidence is graded into four levels:

- high: future research is unlikely to change the level of confidence in the assessment of the effect;
- moderate: future research probably will change the level of confidence in the assessment of the effect and could change the assessment of the effect itself;
- low: future research is very likely to have an impact on the level of confidence in the assessment of the effect and will probably change the assessment of the effect itself;
- very low: the assessment of the effect is highly uncertain.

The level of evidence is analysed for each criteria and then a global level of evidence is defined on the basis of the various evidence levels for the main criteria.

The final formulation of guidelines is always binary, i.e. either positive or negative and either strong or weak:

- strong: recommended or not recommended (GRADE 1+ or 1−);
- weak: probably recommended or probably not recommended (GRADE 2+ or 2−).

The strength of the guideline is determined on the basis of four key factors and validated by the experts after a vote, using the GRADE Grid method [16]:

- assessment of the effect;
- overall level of evidence: the higher this is, the more the guideline will be strong;
- balance between positive and negative effects: the more positive this is, the more likely that the guideline will be strong;
- values and preferences: the greater the uncertainty and variability, the more likely the guideline will be weak. Values and preferences must be ascertained, if possible, directly from those concerned (patient, physician, decision-maker);
- cost: the higher the cost or consumption of resources, the more likely the guideline will be weak.

3. Guidelines

3.1. Guideline 1: internal jugular vein in adults

3.1.1. Question asked

To insert a central venous access via the internal jugular vein in an adult, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.1.2. Data

The results of the meta-analysis demonstrated an 86% reduction in the rate of catheterisation failure (RR: 0.14; 95%CI: 0.09–0.23) in 13 randomised, controlled trials including

2653 patients, an 80% reduction in arterial puncture rates (RR: 0.20; 95%CI: 0.13–0.32) in 13 randomised, controlled trials including 2675 patients, a 78% reduction in the number of haematomas (RR: 0.22; 95%CI: 0.14–0.36) in 9 randomised, controlled trials including 2309 patients, a 90% reduction in the number of cases of pneumothorax (RR: 0.1; 95%CI: 0.02–0.56) in 3 randomised, controlled trials including 1110 patients, a 94% reduction in the number of cases of haemothorax (RR: 0.06; 95%CI: 0–1) in one randomised, controlled trial including 900 patients. The overall level of evidence is good and the risk-to-benefit and the cost-to-benefit ratios are positive.

In all, positive aspects clearly outweigh negative aspects and we propose a strong recommendation.

3.1.3. Guideline

It is recommended that ultrasound-guided puncture be used rather than anatomical cutaneous landmark-based cannulation to insert venous access catheters the internal jugular vein in adults (level 1+).

3.2. Guideline 2: subclavian vein in adults

3.2.1. Question asked

To insert central venous access via the subclavian vein in an adult, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.2.2. Data

The results of the meta-analysis demonstrated a 94% reduction in the rate of catheterization failure (RR: 0.06; 95%CI: 0.01–0.2) in 3 randomised, controlled trials including 498 patients, an 85% reduction in arterial puncture rates (RR: 0.18; 95%CI: 0.04–0.65) in 3 randomized, controlled trials including 498 patients, a 77% reduction in the number of haematomas (RR: 0.23; 95%CI: 0.09–0.68) in 3 randomized, controlled trials including 498 patients, a 78% reduction in the number of cases of pneumothorax (RR: 0.22; 95%CI: 0.05–0.92) in 2 randomized, controlled trials including 446 patients, a 95% reduction in the number of cases of haemothorax (RR: 0.05; 95%CI: 0–0.88) in one randomized, controlled trial including 401 patients. Few studies focus on this approach but the overall level of evidence is high despite heterogeneity and lack of precision in the results for certain key criteria. The risk-to-benefit and the cost-to-benefit ratios are positive.

In all, positive aspects clearly outweigh negative aspects and we propose a strong recommendation.

3.2.3. Guideline

It is recommended that ultrasound-guided puncture be used rather than anatomical cutaneous landmark-based cannulation to insert venous access via the subclavian vein in adults (level 1+).

3.3. Guideline 3: femoral vein in adults

3.3.1. Question asked

To insert a central venous access via the femoral vein in adults, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.3.2. Data

The results of the meta-analysis demonstrated an 85% reduction in the rate of catheterisation failure (RR: 0.15; 95%CI: 0.04–0.52) in 2 randomised, controlled trials including 150 patients, an 86% reduction in arterial puncture rates (RR: 0.14; 95%CI: 0.02–0.74) in 2 randomised, controlled trials including 150 patients and a possible 50% reduction in the number of cases of haemothorax (RR: 0.50; 95%CI: 0.09–2.43) in one randomised, controlled trial including 110 patients. Although there are not many studies on this approach and the overall level of evidence is only moderate because of a lack of precision in the results, the risk-to-benefit and the cost-to-benefit ratios are positive.

In all, positive aspects clearly outweigh negative aspects and we propose a strong recommendation.

3.3.3. Guideline

To insert a central venous access via the femoral vein in adults, ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation (level 1+).

3.4. Guideline 4: radial artery in adults

3.4.1. Question asked

To insert a radial arterial catheter in adults, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.4.2. Data

The results of the meta-analysis demonstrated a 39% reduction in the rate of catheterisation failure at the first attempt (RR: 0.61; 95%CI: 0.41–0.84) in 4 randomised, controlled trials including 281 patients, an 83% reduction in the number of haematomas (RR: 0.17; 95%CI: 0.05–0.54) in 2 randomised, controlled trials including 132 patients. The overall success rate is not reported. Few studies focus on this approach route and the overall level of evidence is low because of the heterogeneity and lack of precision of the results for the critical end point selected. The risk-to-benefit and the cost-to-benefit ratios are probably positive.

In all, positive aspects probably outweigh negative aspects and we propose a weak recommendation.

3.4.3. Guideline

It is probably recommended that ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation to insert a radial arterial catheter in adults (level 2+).

3.5. Guideline 5: peripheral veins in adults

3.5.1. Question asked

When difficult access for peripheral venous access is anticipated in adults, should ultrasound-guided puncture rather than anatomical cutaneous landmark-based cannulation (or palpation) be used?

3.5.2. Data

The results of the meta-analysis demonstrated a 20% increase in the rate of successful catheterisation (RR: 1.20; 95%CI: 0.99–1.33) in 3 randomised, controlled trials including 154 patients. Although there are not many studies on this approach and the overall level of evidence is only moderate because of lack of precision in the results, the risk-to-benefit and the cost-to-benefit ratios are probably positive.

In all, positive aspects probably outweigh negative aspects and we propose a weak recommendation.

3.5.3. Guideline

It is probably recommended that ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation when difficult access for peripheral venous access is anticipated in adults (level 2+).

3.6. Guideline 6: internal jugular vein in children

3.6.1. Question asked

To insert central venous access via the internal jugular vein in children, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.6.2. Data

The results of the meta-analysis demonstrated a 69% reduction in the rate of catheterisation failure (RR: 0.31; 95%CI: 0.18–0.52) in 4 randomised, controlled trials including 460 patients, a 77% reduction in arterial puncture rates (RR: 0.23; 95%CI: 0.11–0.44) in 4 randomised, controlled trials including 460 patients. The overall level of evidence is moderate because of the heterogeneity of the results; the risk-to-benefit and the cost-to-benefit ratios are positive.

In all, positive aspects clearly outweigh the negative aspects and we propose a strong recommendation.

3.6.3. Guideline

To insert central venous access via the internal jugular vein in children, ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation (level 1+).

3.7. Guideline 7: subclavian vein in children

3.7.1. Question asked

To insert central venous access via the subclavian vein in children, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.7.2. Data

No randomised controlled study on the use of ultrasound-guided puncture compared to an anatomical cutaneous landmark-based technique is available on the reduction in complications during insertion of central venous access via the subclavian vein in children.

The authors point out that feasibility studies have been carried out in children focusing on access via the subclavian vein or its extension, the brachiocephalic vein. Infra- or supra-clavicular approaches have been addressed in 7 articles. No complications (arterial puncture or pneumothorax) were reported in any of these studies, which included more than 400 babies and children. Nevertheless, further expert analysis and controlled studies need to be performed.

3.7.3. Guideline

No guideline can be formulated.

3.8. Guideline 8: femoral vein in children

3.8.1. Question asked

To insert central venous access via the femoral vein in children, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.8.2. Data

The results of the meta-analysis demonstrated a 62% reduction in the rate of catheterisation failure (RR: 0.38; 95%CI: 0.19–0.73) and a 65% reduction in arterial puncture rates (RR: 0.35; 95%CI: 0.14–0.83) in 3 randomised, controlled trials including 215 patients. The overall level of evidence is moderate because of a risk of bias and lack of precision in the results; the risk-to-benefit and the cost-to-benefit ratios are positive.

In all, positive aspects clearly outweigh negative aspects and we propose a strong recommendation.

3.8.3. Guideline

To insert a central venous access via the femoral vein in children, ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation (level 1+).

3.9. Guideline 9: radial artery in children

3.9.1. Question asked

To insert a radial arterial catheter in children, should ultrasound-guided puncture or anatomical cutaneous landmark-based cannulation be used?

3.9.2. Data

The results of the meta-analysis demonstrated a 33% reduction in the rate of catheterisation failure at the first attempt (RR: 0.67; 95%CI: 0.45–0.91) in 3 randomised, controlled trials including 300 patients and an 80% reduction in the number of haematomas (RR: 0.2; 95%CI: 0.05–0.65) in one randomised, controlled trial including 118 patients. The overall success rate is not reported. Although there are not many studies on this approach and the overall level of evidence is moderate because of heterogeneous results, the risk-to-benefit and the cost-to-benefit ratios are probably positive.

In all, positive aspects probably outweigh negative aspects and we propose a weak recommendation.

3.9.3. Guideline

It is probably recommended that ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation to insert a radial arterial catheter in children (level 2+).

3.10. Guideline 10: peripheral veins in children

3.10.1. Question asked

When difficult access for peripheral venous access is anticipated in children, should ultrasound-guided puncture rather than anatomical cutaneous landmark-based cannulation (or palpation) be used?

3.10.2. Data

The results of the meta-analysis probably demonstrated a 20% increase in the rate of successful catheterisation (RR: 1.20; 95%CI: 0.89–1.43) in 3 randomised, controlled trials including 134 patients. Few studies focus on this approach and the overall level of evidence is low because of the lack of precision of the results. The risk-to-benefit and the cost-to-benefit ratios are probably positive.

In all, positive aspects probably outweigh negative aspects and we propose a weak recommendation.

3.10.3. Guideline

It is probably recommended that ultrasound-guided puncture should be used rather than anatomical cutaneous landmark-based cannulation when difficult access for peripheral venous access is anticipated in children (level 2+).

Disclosure of interest

Nicolas Fritsch, Frédéric Lapostolle, Sébastien Pierre, Thierry Pirotte and Stéphane Villiers declare that they have no conflicts of interest concerning this article.

Hervé Bouaziz declares having received in the past payments for expert advice from the following companies: B/Braun®, Gamida®, General Electric® and Sonosite®.

Eric Desruennes declares having received in the past payments for expert advice from the following companies: B/Braun® and Perouse®.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.accpm.2015.01.004.

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