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INTENSIVE CARE

Pre-procedure ultrasound increases the success and safety of central venous catheterization†

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Editor's key points

- It is recommended that ultrasound (US) is used to facilitate cannulation of the internal jugular vein (IJV).
- This observational cohort study compared pre-procedural US with landmark techniques for IJV cannulation under general anaesthesia.
- Pre-procedural US was associated with higher success rates, shorter cannulation times, and fewer complications.
- These differences occurred with both experienced and inexperienced operators.

Background. Real-time ultrasound (US) in central venous catheterization is superior to pre-procedure US. However, moving real-time US into routine practice is impeded by its perceived expense and difficulty. Currently, pre-procedure US and landmark (LM) methods are most widely used. We investigated these techniques in internal jugular vein (IJV) catheterization in respect of operator experience, complications, and risk factors.

Methods. In an observational non-randomized study, we investigated 606 of ~1300 procedures, that is, 200 patients were treated under pre-procedure US and 406 under LM [pathfinder (PF) $n=202$, direct cannulation (DC) $n=204$]. We recorded first needle pass success rate, success rate after the third attempt, and the cannulation time. Procedures were performed by inexperienced (<100) or experienced (>100 catheterizations) operators.

Results. Pre-procedure US was associated with more successful attempts and shorter cannulation times. Under pre-procedure US, 88% of first attempts were successful and 100% of third attempts. The median (range) cannulation time was 39 (10–330) s. Under PF, only 56% of first, and 87% of third, attempts were successful with a median (range) cannulation time of 100 (25–3600) s. Under DC, 61% of first and 89% of third attempts were successful; the median (range) cannulation time was 70 (10–3600) s. Remarkably, inexperienced operators using pre-procedure US ($n=38$) were significantly faster than experienced operators using PF or DC ($n=343$) (cannulation time: median 60 s, range 12–330, for inexperienced; 60 s, range 10–3600, for experienced). First puncture success rates were higher (pre-procedure US, inexperienced 84%, PF or DC, experienced 57%).

Conclusions. Pre-procedure US for IJV catheterization is safe, quick, and superior to LM.

Keywords: cannulation time; central venous catheterization; complications; internal jugular vein; success rate; ultrasound

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Anaesthesia-related complications are still a major concern, with central venous (CV) cannulation complications being the leading cause of anaesthesia-related deaths according to one Danish closed claim study.[1] Two-dimensional imaging with real-time ultrasound (US) is superior to external landmark (LM)-guided CV catheterization (CVC) with respect to cannulation success and avoidance of early mechanical complications.[2–4] Real-time US, a technique proved to prevent those complications, is now the recommended method of inserting CV catheters into the internal jugular vein (IJV).[5] Unfortunately, there is a delay between recognizing the benefits and actually implementing real-time US in the clinical environment. This delay arises through concern that real-time US is unsuitable for everyday use, fear of large investments in hardware and training, and the underestimation of the complications arising under current techniques.[6] Regardless of the reasons, the end result is that most practitioners do not have real-time US as an option. They

†This report describes research on humans. IRB contact information: Ethik-Kommission der Friedrich Schiller Universität Jena an der Medizinischen Fakultät. Professor Dr. med. D. Bartz, approved under No.: 1694-01/06. Tel: +49 3641 933770; fax: +49 3641 933771; E-mail: ulrike.skorsetz@med.uni-jena.de. This study was conducted with written informed consent from the study subjects.

must use either pre-procedure US or LM, with LM being their first choice.[7]

In surveys from 2003 and 2007 of German anaesthesiologists, respondents, particularly the longest practicing, overwhelmingly indicated a preference for LM over pre-procedure US.[6 8] We believe that this preference is not unique to German anaesthesiologists, but a global phenomenon. This preference exists despite a mechanical failure rate with LM of 5–19%, and up to 6% even for highly experienced operators.[9 10] The aim of our study was to determine, whether pre-procedure US or LM techniques was the safest and the most successful in a real life clinical environment. We intentionally included the real-life features of differences in operator experience and risk factors (BMI <21 or >32 kg m^{-2}, previous CVC, goitre, left IJV). We recorded success rates, cannulation times, and the occurrence of complications.

Methods

After approval from the local Ethical Committee, we conducted a non-randomized clinical trial of IJV catheterization in an operating theatre of Jena University Hospital. Patients were included if there were indications for CVC as determined by the attending physician and the type of surgery. We included patients more than 12 yr old. Adult patients gave written consent. For non-adult patients (those <18 yr old), parents gave written consent. The exclusion criteria were any contraindications for IJV placement or not being able to obtain written consent (which automatically excluded emergencies).

We compared pre-procedure US with two LM techniques [pathfinder (PF) and direct cannulation (DC)]. We performed pre-procedure US first for 4 months because we were lent a portable Esaote® (MyLab™30CV) US machine for this period by the manufacturer (Esaote Biomedica Deutschland GmbH, Cologne, Germany). Data were recorded from 200 patients. We then performed PF and DC until similar sample sizes had been obtained for each technique (PF=202, DC=204). This took a further 6 months, so the study totalled 10 months in all. Whether PF or DC was used by an operator was determined at random by the supervising investigator tossing a coin. However, DC was never assigned to novices (operators with <50 catheterizations).

We recorded data from 606 IJV catheterizations, all those that took place in the presence of the investigator. Data were not recorded from any others in order to avoid the possibility of inaccurate self-reporting. However, ~1300 IJV catheterizations were performed during the 10 months of the study.

The CVCs were carried out by physicians from Jena University Hospital, Department of Anaesthesiology. Thirteen of these were trainees and 50 postgraduates of year 3 or above and thus of differing degrees of skill and amounts of experience. We divided the 63 operators into experienced (>100 successful unsupervised catheterizations) and inexperienced (with fewer).

All catheterizations were supervised by a single investigator who also recorded the results, so avoiding inter-investigator differences. The investigator also documented the characteristics of the patients and operators and also any complications that occurred. The data recorded were the number of cannulation attempts, the first needle pass success rate, third attempt success rate, cannulation time, and early mechanical complications. The first needle pass success rate was defined as successful IJV cannulation with a wide-bore needle. A cannulation attempt was defined as a single skin puncture. Any attempt with a seeker needle was documented separately. Cannulation time was measured from 'needle to skin to J-wire in'.

Because previous CVC, BMI <21 or >32 kg m^{-2}, goitre, and CVC via the left IJV are associated with more complications under LM,[10–14] we recorded these details. We defined goitre as a visibly enlarged thyroid gland (WHO grade III). Complications recorded included haematoma and pneumothorax. Severe haematoma was defined as a visible haematoma large enough to compromise the airway (without any particular technical assessment).

All CV catheters were inserted with the Seldinger technique using a Certofix® Trio (B. Braun Melsungen AG, Germany). Most CVCs were performed in patients under general anaesthesia and mechanical ventilation (tidal volume 6–8 ml kg^{-1}, PEEP 5 cm H_2O). Otherwise ($n=84$), CVC was performed under local anaesthesia using 1% lidocaine at the cannulation site. All patients were placed in a 30° Trendelenburg supine position with the head in a neutral position.

Pre-procedure US

This involved scanning the neck and antero-lateral vessel area with two-dimensional US before cannulation. Scans were made using a portable Esaote® machine (MyLab™30CV, Esaote Biomedica Deutschland GmbH) with an 18–6 MHz linear-array probe. Both left and right IJVs were evaluated in terms of their course, calibre, patency, and relationship to the carotid artery. No skin markings were applied. The cannulation site was subsequently prepared and draped under sterile precautions. The vein was punctured with an 18 G needle without the use of a seeker needle, palpation of external LMs, or of the carotid artery.

LM techniques

After sterile preparation of the cannulation site, the anticipated position of the IJV was identified by external LMs. The approach used (central, anterior, or posterior) depended on operator preference. PF used a 21 G seeker needle to identify the IJV. The vein was then punctured with a wide-bore needle, while the fine gauge needle remained in place. DC was carried out using an 18 G needle for direct IJV puncture.

Rescue US

Catheterization failure was defined as no success after three attempts, no success within 10 min, or if there were complications. Under any of these three circumstances, operators were able to request rescue US, but it was not mandatory to do so. CVCs requiring rescue US were excluded from the study as they were then no longer true LM.