# The use of ultrasound to identify veins for peripheral venous access in morbidly obese patients

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## ABSTRACT

**INTRODUCTION:** Peripheral intravenous access (PIA) is a necessity in the treatment and monitoring of the majority of hospitalised patients. Patients with an increased body mass index (BMI) more often than normal-weight patients have a difficult PIA. Identifying veins with ultrasonography has proven helpful when facing a difficult intravenous (IV) access. We hypothesise that, with the help of ultrasonography (US), it is possible to identify at least one vein suitable for IV access in morbidly obese patients (BMI > 40 kg/m$^2$).

**METHODS:** We included 55 morbidly obese patients with a BMI > 40 kg/m$^2$. We performed a detailed US of seven anatomic areas routinely used for PIA. We present a description of parameters that are relevant when attempting PIA.

**RESULTS:** In our study group, all patients had a minimum of one peripheral vein that was suitable for peripheral venous access, including seven patients (12.7%) who did not have clinically detectable veins.

**CONCLUSIONS:** With the aid of ultrasound it is possible to identify a minimum of one peripheral vein suitable for IV access in morbidly obese patients.

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Peripheral intravenous access (PIA) is a necessity for treatment and monitoring in the majority of hospitalised patients, and it is always required for patients undergoing surgery. For some patients an intravenous (IV) access of sufficient caliber is urgently needed for life-saving treatment. IV lines are usually established quickly by use of venous stasis, eyesight and palpation. A patient's physical constitution or present illness can make it difficult and sometimes impos-sible to obtain a PIA.

The number of overweight patients and the degree of overweight has increased worldwide during past decades and this trend seems to continue. Obesity is widely believed to be associated with difficult PIA. Ultrasound (US) guidance for vascular access has formed part of clinical practice for more than 30 years [1]. In our experience, the use of US can be helpful in locating superficial peripheral veins in patients with an increased body mass index (BMI) in elective as well as emergency cases.

Several studies show an improved success rate and reduced time spent when using US for difficult PIA [2-9]. Using US for PIA results in fewer central venous catheter placements, which reduces the complications associated with this procedure [2, 6]. Difficulty in obtaining a venous access is painful and unpleasant for the patient. In these situations, using US has been shown to increase patient satisfaction [3, 10].

Witting et al found that vein diameter is the parameter with the strongest correlation to a successful PIA. Success rates for PIA are higher in larger veins with a iameter exceeding 0.4 cm and in veins located at moderate depth from 0.3-1.5 cm [11].

In the present study, we included morbidly obese patients with a BMI > 40 kg/m$^2$ and performed a detailed US scan of anatomic areas routinely used for PIA. We identified the regions most likely to hold a vein suitable for PIA and presented a description of the parameters that are relevant when attempting PIA. We hypothesised that with the guidance of US, it is possible to identify at least one vein that is suitable for PIA in morbidly obese patients.

## METHODS

The study protocol was approved by the Committees on Biomedical Research Ethics of the Capital Region of Denmark (protocol no. H-B-2009-059) in accordance with the Helsinki II Declaration). After written informed consent, 55 patients scheduled for laparoscopic gastric bypass or gastric banding surgery were included in the study. The inclusion criteria were: age > 18 years and BMI > 40 kg/m$^2$. The exclusion criteria were former or current deep venous thrombosis in order to exclude patients with potential post-thrombotic syndrome. No patients were excluded.

A total of seven pre-defined anatomic regions were investigated bilaterally in each patient: 1) the dorsal side of the hand; 2) the antecubital fossa; 3) the medial bicipital groove on the arm; 4) the dorsal side of the foot; 5) the region over the medial malleolus of the ankle; 6) the inguinal region overlying the femoral vein; and 7) the region of the neck overlying the external jugular vein.

The patients rested in a bed in supine position at an ambient room temperature of approximately 21 ºC. We used venous stasis on the extremities for 30 seconds prior to the measurements on the foot, hand, forearm and arm. All examinations and measurements were per-

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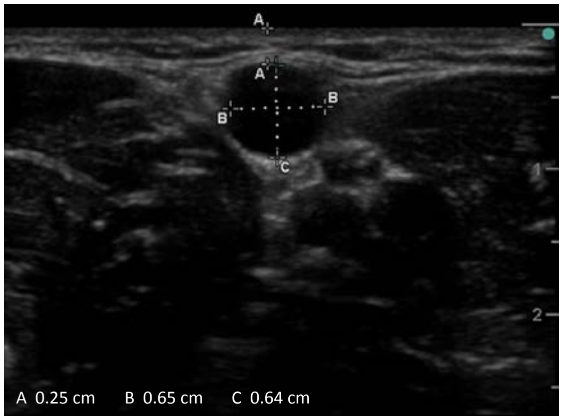
FIGURE 1

How vein depth and diameter was measured using ultrasound.




A-A = vein depth.
B-B = cross-sectional vein diameter.
C-C = cross-sectional vein diameter.

formed by one of two residents trained in peripheral venous US.

For each of the seven regions, the following parameters were registered: visible vein and palpable vein. By use of a high-frequency linear US transducer system (HFL 12.7 × 47.1 mm, 5-13 MHz, GE Logiq e, Wauwatosa, WI, USA) and appropriate acoustic coupling, we scanned each region and identified veins suitable for cannulation. When more than one vein was identified with US in a region, data from the vein most suitable for cannulation were registered.

Veins were identified as: superficial veins (depth ≤ 10 mm) or deeper veins (depth > 10 mm). Vein depth was measured as the shortest distance from the skin to the inner venous wall (Figure 1). If more superficial veins were identified, the most superficial vein with a cross-sectional diameter of more than 2.5 mm was chosen. If only smaller veins were present, the most superficial vein was chosen. When deeper veins were identified, the vein with the largest cross-sectional diameter was measured (**Figure 1**). If both superficial and deeper veins were identified, a cross-sectional diameter > 2.5 mm had a higher priority than vein depth. The US probe was oriented to obtain a cross-sectional view of the vein and to optimise the image with respect to gain and depth. The smallest possible pressure was applied to the skin when optimising US images. When the optimal image was obtained, we used the freeze function and measured cross-sectional diameter and depth using the caliper function (Figure 1). Doppler flow in the vein was also recorded to verify venous flow. If venous stasis had been applied, Doppler flow was recorded immediately after the venous stasis was released.

Data are presented as numbers and mean (standard deviation (SD)). The SPSS software package (SPSS Statistics, version 20.0.0, SPSS, Chicago, IL, USA) was used for all calculations.

*Trial registration:* not relevant.

TABLE 1

Patient characteristics.

| | |
|---|---|
| Male/female, n | 24/31 |
| Age, yrs, mean (± SD) | 37 (± 6.2) |
| Body mass index, kg/m$^2$, mean (± SD) | 46.2 (± 4.6) |

SD = standard deviation.

## RESULTS

The study included 55 patients (**Table 1**). Vein characteristics from bilateral measurements in the seven pre-defined anatomic regions are presented in **Table 2**. A total of four patients had an intravenous catheter inserted on the dorsal side of one hand prior to inclusion. Therefore, only 106 measurements were possible for this region. In seven patients, peripheral veins were neither visible nor palpable in any of the seven pre-defined regions. None of these patients had an intravenous catheter in place at the time of our study. We used the independent samples t-test (not assuming equal variances) to compare means of BMI and vein depth (assuming equal variances) between patients with and without clinically detectable veins. Equality of variances was tested using Levene's test. We found that the mean BMI was significantly higher in the seven patients without clinically detectable veins ($p = 0.027$). Vein depth was significantly deeper on the dorsal hand ($p = 0.02$), on the dorsal side of the foot ($p = 0.019$) and in the inguinal region ($p = 0.009$) in the seven patients without clinically detectable veins. In the other four regions, mean depth was deeper in those seven patients, but not significantly so. US characteristics of their veins are presented in **Table 3**. All patients had US detectable veins in all seven regions.

## DISCUSSION

We have presented a detailed description of the regions routinely used for PIA. Only seven patients were without clinically detectable veins. This implies that in many cases, a thorough clinical examination would yield a usable vein even in obese subjects and that knowledge of the potential sites for successful IV access could improve the success rate for IV placements. The seven patients (12.7%) without clinically detectable veins had a mean BMI of 51.5 kg/m$^2$ which is significantly higher than patients with palpable or visible veins. The mean depth of vein was larger in all seven regions in this group, but only significantly so in three regions, possibly because of the small sample size.

Table 3 shows that with the use of ultrasound it is possible to find a vein that meets the criteria associated with a successful PIA, as presented by Witting et al [11], even in the morbidly obese patients. All patients in our study had US-identifiable veins in five of the seven examined locations. No patient had more than one hand or foot without US identifiable veins. 99% of all patients had a US-identifiable vein in the antecubital fossa and 100% in the medial bicipital groove and the neck overlying the external jugular vein. Both of these regions are accessible in emergency situations.

Veins in the antecubital fossa, the medial bicipital groove and the neck overlying the external jugular vein met the criteria for a successful US-guided PIA. This also applied to the seven patients with no visible or palpable veins, except that the mean depth in the medial bicipital groove in these patients was 1.54 cm. The mean diameter was 0.63 cm which means that in many cases this would be a suitable region for US-guided PIA.

The inguinal region was included in the study as the femoral vein. Even though it is not routinely used for PIA, the femoral vein is important for venous access in emergency situations. The vein is relatively deeply located with a mean depth of 20.1 mm, but has a large mean diameter of 8.9 mm (Table 2).

The quality of veins on the hands and feet were characterised by an expectedly large individual difference. As our data showed, the dorsal hand is superior to the dorsal foot on all parameters measured. The ankle offers an acceptable alternative. The diameter is smaller; however, the veins lie deeper in this region compared with the antecubital fossa.

Several studies, including paediatric studies, have shown the benefits of using US for PIA in terms of an improved success rate, reduced time consumption, fewer central venous catheter placements and increased patient satisfaction [2, 3, 5-8, 10, 12].

The patients in our study were morbidly obese, but otherwise healthy young adults. Meeting the same type of patient in emergency settings, e.g. septic, hypothermic or hypovolemic patients would obviously change the clinical as well as the ultrasonic findings.

Our study had some important limitations: the generally good condition of the elective patients poorly mimics the oftentimes hypovolemic state of emergency

**TABLE 2**

Vein characteristics from bilateral measurements in seven predefined regions in 55 morbidly obese patients.

| | Dorsal hand | Antecubital fossa | Medial bicipital groove, arm | Dorsal foot | Medial malleolus, ankle | Neck region overlying the external jugular vein | Inguinal region overlying the femoral vein |
|---|---|---|---|---|---|---|---|
| Visible veins/NM, n (%) | 66/106 (62.3) | 24/110 (21.8) | 0/110 | 57/110 (51.8) | 12/110 (10.9) | 19/110 (17.3) | 0/110 |
| Palpable veins/NM, n (%) | 61/105 (58.1) | 67/110 (60.9) | 0/110 | 28/110 (25.5) | 29/110 (26.4) | 20/110 (18.2) | 0/110 |
| Veins detected by US/NM n (%) | 104/110 (94.5) | 109/110 (99.1) | 110/110 (100) | 105/110 (95.5) | 110/110 (100) | 110/110 ( 00) | 110/110 (100) |
| Doppler flow/NM, n (%) | 96/105 (91.4) | 109/110 (99.1) | 110/110 (100) | 82/107 (76.6) | 110/110 (100) | 110/110 (100) | 110/110 (100) |
| Vein depth[a], mm, mean (range) | 2.1 (0.9-3.5) | 3.6 (1.1-9.1) | 13.9 (6.5-22.2) | 2.1 (0.6-4.5) | 4.9 (1.2-13.2) | 5.6 (1.8-14.0) | 20.1 (9.1-33.9) |
| Vein diameter[b], mm, mean (range) | 2.1 (0.8-3.4) | 4.9 (2.7-8.5) | 6.2 (2.9-10.8) | 1.5 (0.5-3.6) | 3.3 (1.4-5.1) | 5.22 (2.1-14.1) | 8.9 (4.3-15.5) |

NM = number of measurements in the specific region; US = ultrasound.
a) Measured as the shortest distance from the skin to the inner venous wall (Figure 1).
b) Measured as largest cross-sectional diameter.

**TABLE 3**

Ultrasound characteristics of veins in the seven patients with neither visible nor palpable veins in any of the seven predefined regions.

| | Dorsal hand | Antecubital fossa | Medial bicipital groove | Dorsal foot | Medial malleolus, ankle | Neck region overlying the jugular vein | Inguinal region overlying the femoral vein |
|---|---|---|---|---|---|---|---|
| Veins detectable by US/NM, n (%) | 14/14 (100) | 14/14 (100) | 14/14 (100) | 14/14 (100) | 14/14 (100) | 14/14 (100) | 14/14 (100) |
| Doppler flow/NM, n (%) | 14/14 (100) | 14/14 (100) | 14/14 (100) | 8/14 (57.1) | 14/14 (100) | 14/14 (100) | 14/14 (100) |
| Vein depth[a], mm, mean (range) | 2.8 (2.2-3.5) | 4.5 (3.1-6.9) | 15.3 (10.1-21.3) | 2.8 (2.0-4.1) | 6.2 (3.1-11.6) | 7.5 (4.1-11.2) | 25.3 (17.9-33.9) |
| Vein diameter[b], mm, mean (range) | 1.9 (0.8-3.2) | 4.6 (3.9-5.9) | 6.3 (5.0-8.2) | 1.2 (0.8-1.8) | 3.6 (2.8-4.4) | 6.5 (3.2-14.1) | 10.4 (6.9-13.9) |

NM = number of measurements in the specific region; US = ultrasound.
a) Measured as the shortest distance from the skin to the inner venous wall (Figure 1).
b) Measured as largest cross-sectional diameter.

care. As a cannula was not inserted after identifying the vein, it is not possible to say whether the use of US would, in fact, have resulted in a successful PIA. Identifying peripheral veins with US is quickly learned, but actually inserting an US-guided PIA by free hand requires some training and success is operator-dependent [7, 8, 13-15].

Furthermore, we did not scan the antebrachium; this region would presumably hold veins that could be used for PIA, e.g. the basilica vein. It may be argued that time spent identifying suitable veins for cannulation should have been registered. A prospective cohort study in an emergency department has shown that a median time of three minutes (2-7 minutes) for US-guided initial venous cannulation is required [8]. Another study found that time required was 8-9 minutes, not taking into account time for set-up [16].

Examinations were performed by only one of two investigators. If all patients had been examined by several investigators, we could have estimated the degree of interobserver agreement in identifying veins suitable for PIA, clinically as well as US-guided agreement. However, a study by Planken et al has previously shown that similar measurements of the forearm cephalic vein are observer independent [17].

Some studies imply that to increase the survival time of US-guided catheters, longer catheters may be useful [7, 8]. Due to excess subcutaneous fat, veins in the morbidly obese lie deeper, why inserted catheters would, theoretically, be dislodged more easily. For the morbidly obese patient, it may be indicated to use longer catheters. This needs to be further investigated before any general recommendations can be made.

On the basis of our results, we suggest that US-guided peripheral vascular access could be considered a first-line choice to guide PIA in morbidly obese patients when there are no clinically detectable veins as US can save time and decrease patient discomfort in both emergency and non-emergency situations.

Though peripheral are veins easily visualised with US, even in patients without clinically detectable veins, success in US-guided PIA requires training. We suggest that training of relevant staff in this skill should be implemented.

Our data do not allow us to recommend one specific region for US-guided PIA, as the choice of region and time spent on scanning depends on the clinical situation.

Our hypothesis was that US offers the possibility of identifying a vein suitable for PIA in morbidly obese patients. We believe our results substantiate this.

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**CONFLICTS OF INTEREST:** Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk

## LITERATURE

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