Evidence Profile

Recommendation Question 6: Is the use of visualization technologies (e.g., ultrasound, vein finders) for the insertion of peripheral IVs more effective in improving person and provider outcomes?

Recommendation 6.2: The guideline panel suggests that health providers use ultrasound-guided technique for the insertion of PVADs in persons with difficult intravenous access.

Population: Nurses and the interprofessional team
Intervention: use of visualization technology (e.g. ultrasound, vein finders) for the insertion of peripheral vascular access devices (PVADs)
Comparison: Standard practice
Outcomes: Success rate on first attempt/number of failed attempts, patient satisfaction, complications (i.e. phlebitis, infiltration, extravasation, infection, bleeding, embolism)
Setting: All practice settings where patients with vascular access devices are cared for (e.g., primary care, long-term care, acute care, community care)

Bibliography: 7750, 3384, 973, 856, 1458, 204, 1549, 1062, 210

Quality assessment							Summary of Findings		No. of Participants		Reported Effects/Outcomes	Certainty	Reference
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Country	Intervention	Intervention	Control			
Success rate on first attempt/number of failed attempts (assessed by: number of attempts to achieve a successfully inserted PVAD, first attempt success rate, or global success rate.)													
1[a]	Systematic review and meta-analysis of RCTs	Serious[b]	Serious[c]	Not serious	Not serious[d]	Not detected	973: not specified	973: **Ultrasound guided PVAD insertion** versus traditional methods (with option of transillumination in one study). 3 studies examined children were aged <3 to 10 years old. 6 studies examined adults. Operators included physician operated US with nurse inserting catheter, or anesthesiologists and nurse anesthetists. Studies included in the review examined patients with	973: n=376 participants, 174 insertion attempts Peds ED:1 study, Mean difference -2.00 [-2.73, -	973: n=158 insertion attempts	Overall, meta-analyses demonstrated a positive trend favouring US-guided insertion of PVADs over traditional methods for persons with DiVA. Additional RCTs also found that the use of US-guided technique improved success rate on first attempt for PVAD insertion in persons with difficult intravenous access.[e] 973: Meta-analyses demonstrated a positive trend favouring US-guided insertion of PVADs over traditional methods for difficult access patients in pediatric	⊕○○○ VERY LOW	973: Heinrichs, Fritze, Vandermeer, Terry Klassen & Curtis (2013)

Quality assessment							Summary of Findings		No. of Participants		Reported Effects/Outcomes	Certainty	Reference
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								difficult intravenous access (DiVA), defined as patients with failed previous PVAD attempts, or had at least one limb where no vein was visible or palpable.	1.27] Peds OR:1 study,Mean difference -1.50 [-2.52, -0.48] Adult ED:3 studies, Mean difference -0.43 [-0.81, -0.05] Adult ICU (did not examine attempts, only risk of failure)1 study, RR 0.47 [0.26, 0.87] Adult OR:2 studies, Mean difference -0.40 [-1.85, 1.05]		EDs, pediatric ORs, adults EDs, adult ICU, and adult OR.		
							3384: France	**Additional RCTs included:** 3384: Placement of a PVAD using an ultrasound-guided method (UGM), versus placement of a PVAD using the landmark method (LM). Participants were those with difficult vein access, and ranged from 52-75.8 years old, with various admission causes. Nurses completed an ultrasound training program prior to doing insertions.	3384: n=57 First day success rate: 66% (RR 0.95, CI 0.74-1.22) Global success rate: 98% (RR 1.04, CI 0.97-1.11).	3384: n=57 First day success rate: 70%, p=0.886 Global success rate: 95%, p=0.618	3384: The crude median number of attempts did not differ between the UGM and the LM groups (2 (1–4) in both groups. For every 100 people who receive intervention, 4 less people will have outcome (ranges from 18 less to 15 more for first day		3384: Bridey et al. (2018)

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							856: Denmark	856: Patients were catheterised twice and were randomised to either start with: (1) Ultrasound guided Dynamic Needle Tip Positioning (DNTP) or (2) The traditional palpation technique. All children were less than 4 years old, and anaesthetised with sevo flouran inhalation prior to the catheterization attempts by an independent anaesthetist. A tourniquet was placed and the limb was scanned attempting to visualise eligible veins in the short-axis view. Both procedures were considered successful when 5 ml isotonic sodium chloride was infused and absence of swelling was registered. Five paediatric anaesthesiologists participated as operators in the study.	856: n=25 First attempt success rates: 42/50 (84%), p=0.029 Overall success rate: 50/50 (100%), p=0.008	856: n=25 (note: participants acted as own controls) First attempt success rates: 30/50 (60%) Overall success rate: 42/50 (84%)	success rate). For every 100 people who receive intervention, 4 more people will have outcome (ranges from 3 less to 10 more for global success rate). 856: First attempt success rates for PVAD insertion were higher in the ultrasound-guided group than the control (RR 1.4, 95% CI 1.08-1.81). For every 100 people who receive intervention, 24 more people will have outcome (ranges from 5 more to 49 more for first attempt success). Overall success rate: RR 1.10, CI 1.05-1.35. For every 100 people who receive intervention, 16 more people will have outcome (ranges from 4 more to 29 more).		856: Gopalasingam et al. (2017)
							1458: Brazil	1458: For the experimental group, PVAD insertion was guided by ultrasound. Two nurses carried out the procedure; 1 performed the insertion and the other	1458: n=188 Successful insertion	1458: n=194	1458: Successful PVAD placement was more frequent		1458: Avelar,

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								provided the required support. In the control group, the PVAD insertion was performed using the standard anatomical landmark technique with venous palpation and visualization. Children aged 1 day to 18 years old were included, with different levels of venous access difficulty and different ages and behavior that may have influenced their cooperation with the procedure.	attempts: 161 (85.6%)	Successful insertion attempts: 178 (91.8%)	in the CG than in the EG, with no significant differences between the groups (RR 0.93, 95% CI 0.87- 1.00). For every 100 people who receive intervention, 7 less people will have outcome (ranges from 12 less to 0 (no difference)).		Peterlini & Pedreira (2015)
							204: USA	204: Pediatric patients with predicted DiVA were allocated to the ultrasound group or the traditional group, stratified by age (older or younger than 3 years). The PVAD was placed by an available study team member. Ultrasonographically guided intravenous lines were placed by a single operator using the dynamic technique in the short axis, whereby the PVADis placed under direct ultrasonographic guidance, with the probe held in transverse position.	204: n=83 First attempt success: 70 (85.4%) Second attempt success: 78 (95.1%) Third attempt success: 80 (97.6%)	204: n=84 First attempt success: 38 (45.8%) Second attempt success: 63 (75.9%) Third attempt success: 74 (89.2%)	204: Positive (favours USG).The first-attempt success was 45.8% in the traditional PVAD group and 85.4% in the USG PVAD group. The relative risk for first-attempt success was 1.9 (95% CI 1.5 to 2.4). For every 3 USG PVAD placement attempts, 1 missed attempt was prevented compared with that for a traditional PVAD insertion.		204: Vinograd et al. (2019)
							1549: USA	1549: For subjects randomly assigned to ultrasonography, the technician used an ultrasonography machine to visualize an acceptable vein [for PVAD insertion]. The technician prepped the site with a chlorhexidine swab and sterile lubrication gel. Next, the technician used a dynamic,	1549: n=605 Initial success rate: difficult access 81.6%, moderately difficult 81.2%, easy access	1549: n=584 Initial success rate: difficult access	1549: For difficult and moderately difficult access patients, results were positive, favouring the US-guided group		1549: McCarthy et al. (2016)

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								single-operator technique that involved holding the probe in the nondominant hand and concurrently inserting the needle and advancing the catheter into the vein with the other hand, using the ultrasonography machine to visualize and guide the needle. For subjects randomly assigned to landmark, the technician secured a tourniquet around the chosen arm and palpated to identify an acceptable vein. Patients were assessed for difficulty of access, and stratified based on whether they were classified as difficult access, moderately difficult, or easy access.	85.9%	35.1%, moderately difficult 71.4%, easy access 96.6%	(difficult access: RR 2.32 [1.74-3.11], moderately difficult: RR 1.14 [1.01-1.27]).		
							1062: Turkey	1062: Patients were randomized to PVAD insertion using ultrasound or by the traditional method. All patients had a history or suspicion of difficult cannulation.	1062: n=30 Success rate: 21/30 (70%) First attempt success: 6/30 (20%)	1062: n=30 Success rate: 9/30 (30%) First attempt success: 3/30 (10%)	1062: Results were positive favouring the US group. For every 100 people who receive the intervention, 40 more people will have successful insertion (ranges from 9 more to 97 more).		1062: Ismailoglu et al. (2015)
							210: USA	210: Study nurses in the US arm used an US machine with a high-frequency linear transducer for US-guided PVAD insertion. All included participants classified as difficult access, and all were adults. Patients in the control group received standard of care (palpation technique).	210: n=63 Success rate: 48/63 (76%)	210: n=59 Success rate: 33/59 (56%)	210: Results were positive favouring the US-guided group. The odds ratio for success for the US-guidance arm was 2.52 (95% CI, 1.09-5.92) times the odds of success for the standard care arm.		210: Bahl et al. (2016)
Complications (including: infiltration, phlebitis arterial puncture, nerve puncture)													

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1[f]	Systematic review of RCTs and non-RCTs	Very serious[g]	Not serious	Not serious	Very serious[h]	Not detected	7750: Multiple (specific countries not stated) 1458: Brazil	7750: The objective of this study was to compare ultrasound guidance with the traditional approach of palpation and direct visualisation forPVAD insertion. Settings included the emergency department, ICU, and operating room. IV insertions were performed by nurses and physicians. 6 of the 7 included studies examined only persons with difficult intravenous access (DiVA). One study stratified the results by DiVA level of the participants. **Additional RCTs included:** 1458: For the experimental group, PVAD insertion was guided by ultrasound. Two nurses carried out the procedure; 1 performed the insertion and the other provided the required support. In the	7750: Two studies registered the complications infiltration, arterial puncture, and nerve puncture. Details taken from primary studies: 4/98 complication events in one study, 12/41 in the other (total: 16/139, 12%) 1458: n=188 # of catheters removed due to adverse events: 111	7750: N of complication (taken from primary studies)= 22/34 in one study, 5/94 in the other (total: 27/128, 21%) 1458: n=194	Overall the review found that the use of US-guided technique for persons with DiVA resulted in a decreased number of complications. The additional studies included had mixed results, one RCT supported this finding while the other RCT found there were more complications in the US group. 7750: - There were decreased number of complications with the use of ultrasound guided technique. For every 100 people who receive ultrasound, 9 less people will have complications (ranges from 14 less to1 less). 1458: With regard to the complications observed, the incidence of	⊕○○○ VERY LOW	7750: van Loon, Buise, Claasen, Dierick-van Diele, & Bouwman (2018) 1458: Avelar, Peterlini & Pedreira (2015)

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								control group, the PVAD insertion was performed using the standard anatomical landmark technique with venous palpation and visualization. Children aged 1 day to 18 years old were included, with different levels of venous access difficulty and different ages and behavior that may have influenced their cooperation with the procedure. 204: Pediatric patients with predicted DiVA were allocated to the ultrasound group or the traditional group, stratified by age (older or younger than 3 years). The PVAD was placed by an available study team member. Ultrasonographically guided intravenous lines were placed by a single operator using the dynamic technique in the short axis, whereby the PVAD is placed under direct ultrasonographic guidance, with the probe held in transverse position.	(32.7%) Infiltration: 57 (16.8%), p=0.025 Phlebitis: 9 (2.6%) 204: n= 26 out of 65 USG PVAD insertions had reported complications (40%; 95% CI 30% to 53%) (relative risk 0.84; 95% CI 0.53 to 1.34).	204: n=19 out of 40 traditional PVAD insertions had reported complication (48%;95% CI 34% to 66.5%).	infiltration differed significantly between the groups, occurring more frequently in the ultrasound group. Phlebitis occurred nearly 4 times more frequently in the control group. 204: Complications included phlebitis, infiltration, pain, leakage, bleeding, unintentional dislodgement, and line occlusion. Results trended towards favoring ultrasound. For every 100 people who receive ultrasound, 8 less people will have outcome (ranges from 22 less to 15 more).		204: Vinograd et al (2019)
							204: USA						
Patient satisfaction (assessed with a survey, or unspecified measurement)													
1[i]	Systematic review of	Not serious[j]	Not serious	Not serious	Serious[k]	Not detected					The review found that patient satisfaction was increased with the use of US guided	⊕⊕⊕◯ MODERATE	

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	RCTs						973: not specified 3384: France 204: USA	973: **Ultrasound guided PVAD insertion** versus traditional methods (with option of transillumination in one study). 3 studies examined children were aged <3 to 10 years old. 6 studies examined adults. Operators included physician operated US with nurse inserting catheter, or anesthesiologists and nurse anesthetists. Studies included in the review examined patients with difficult intravenous access (DiVA), defined as patients with failed previous PVAD attempts, or had at least one limb where no vein was visible or palpable. **Additional RCTs included:** 3384: Placement of a PVAD using an ultrasound-guided method (UGM), versus placement of a PVAD using the landmark method (LM). Participants were those with difficult vein access, and ranged from 52-75.8 years old, with various admission causes. Nurses completed an ultrasound training program prior to doing insertions. 204: Pediatric patients with predicted DiVA were allocated to the ultrasound group or the traditional group, stratified by age (older or younger than 3 years). The PVAD was placed by an available study team member. Ultrasonographically	973: 129 participants numbers in intervention vs. control groups not specified). 3384: n=57 Median (IQR): 8 (7–9) 204: n=83	973: not specified 3384: n=57 Median (IQR): 8 (7–9.5), p=0.543 204: n=84	technique for PVAD insertion. One additional RCT included supported this result, and one RCT found equivalence in satisfaction between groups. 973: In all 3 trials, satisfaction with the USG procedure was higher but not statistically significant. (Note: No raw data on satisfaction scores was provided). 3384: Patient satisfaction was high in both groups, demonstrating equivalence between the groups. 204: Parents were more satisfied with USG PVAD placement compared with traditional placement (median		973: Heinrichs, Fritze, Vander-meer, Terry Klassen & Curtis (2013) 3384: Bridey et al. (2018) 204: Vinograd et al (2019)

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								guided intravenous lines were placed by a single operator using the dynamic technique in the short axis, whereby the PVADis placed under direct ultrasonographic guidance, with the probe held in transverse position.			10 [interquartile range 8 to 10] versus 8 [interquartile range 5 to 10]; median difference 2 [95% CI 0.9 to 3.1]).		

Explanations

PVAD = peripheral vascular access device

IV = intravenous

DiVA = difficult intravenous access

CI = confidence interval

IQR = interquartile ratio

ED = emergency department

ICU = intensive care unit

OR = operating room

USG = ultrasound guided

[a] One systematic review (of 9 RCTs) was included for this outcome. Seven additional RCTs published after the SR or not included in the SR were included for the outcome of success rate on first attempt (3384, 856, 1458, 204, 1549, 1062, and 210). The findings support the results of the SRs and were not GRADED separately.
[b] Review 973 assessed for risk of bias (ROB) in the included RCTs using the Cochrane ROB tool. 5 studies were rated as low ROB, 3 as unclear and one as high, due to concerns with allocation concealment and missing outcome data. We downgraded by 1.
[c] Review 973 notes high heterogeneity in the studies based on differing settings and populations. We downgraded by one.

[d] Review 973 had a total of 332 events (less than optimal 400). We downgraded by 0.5

[e] One systematic review examined the effect of near-infrared devices on the outcome of success rate of first attempt for PVAD insertion, however the results were inconclusive and did not directly pertain to this recommendation, thus were not included in the final GRADE analysis for this recommendation.

[f] One systematic review with a total of 8 studies included, 2 of which examined complications as an outcome (1 RCT, 1 cohort study). Two additional RCTs were included for the outcome of complications (1458 and 204). Study 1458 found that infiltration occurred more frequently in the ultrasound group and phlebitis occurred nearly 4 times more frequently in the control group. Study 204 found there were slightly less complications in the USG group, but the results were not clinically or statistically significant.

[g] The two studies in the systematic review that examined complications as an outcome were assessed for ROB using the Cochrane ROB 2.0 tool and the ROBINS tool. The RCT was rated as high ROB due to concerns with the randomization process and selection of the reported results. The non-RCT was rated as critical ROB due to concerns with confounding and deviations from the intended interventions. We downgraded by 2.

[h] The total number of events of complications was <100 with no confidence intervals given. We downgraded by 2.

[i] Review 973 included a total of 9 RCTs, 3 of which examined the outcome patient satisfaction. Two additional RCTs were included for the outcome of patient satisfaction (3384, 204). Study 3384 found equivalence in satisfaction between the intervention and control groups, and study 204 reported increased parental satisfaction in the intervention group.

[j] Review 973 assessed ROB using the Cochrane ROB tool. Two studies that examined the outcome of patient satisfaction were rated as low ROB, and one study was rated as unclear ROB. We downgraded by 0.5

[k] The number of participants was 129 (less than optimal 400). We downgraded by 1.