What training for ultrasound-guided placement of short peripheral cannulas?

Kathy Kokotis RN BS MBA

VAT Consulting

E-mail:
kathy.kokotis@gmail.com

Mobile: (+1)219-730-8927
WhatsApp

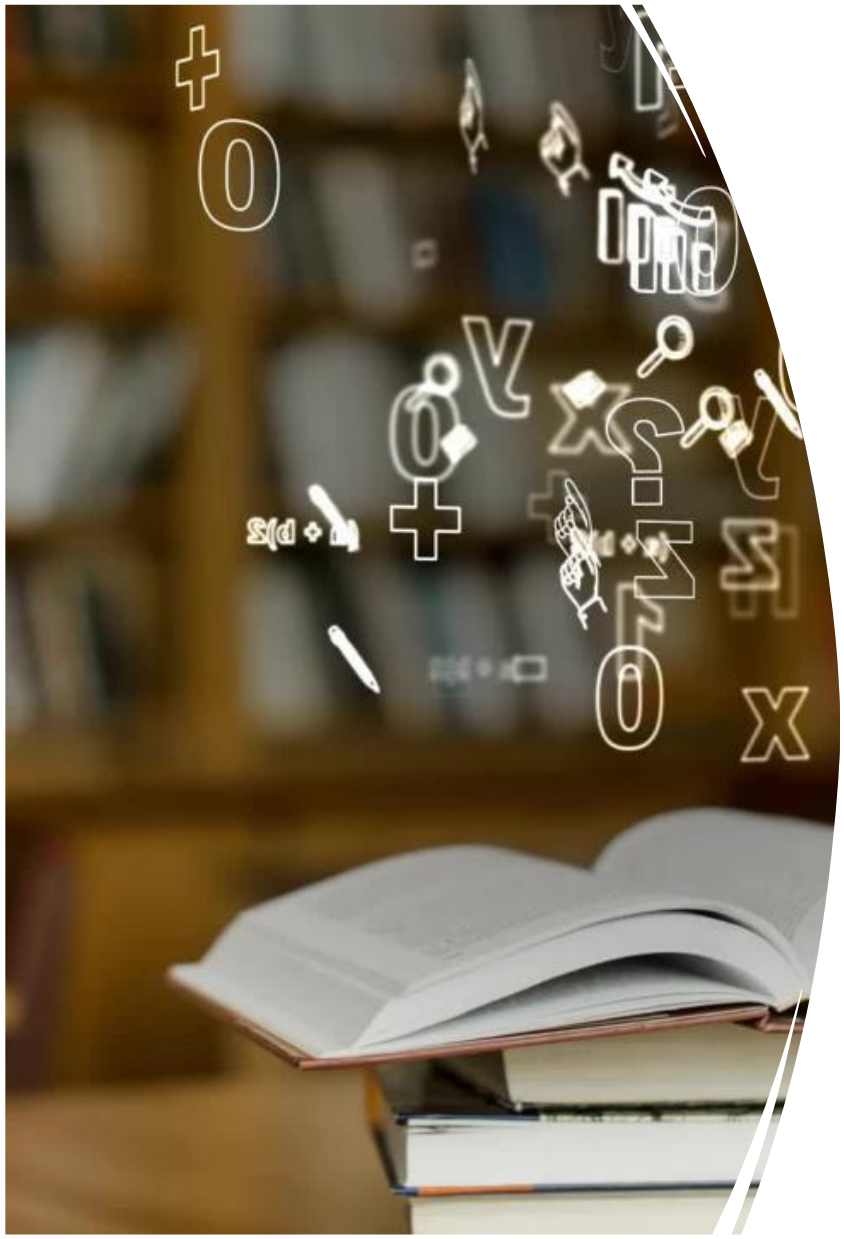
What training?

Learning curve in the published literature

Training methodologies
Stolz (2016)
Loon (2022)

Competency and assessment

Proposed Training summation



Learning curve
The published literature

The term was introduced to medical in the 1980’s

Minimal access surgeries

Definition: learning curve clinical perspective

- Became famous when a British surgeon said during the surgeon learning curve there was a high death rate
- The number of procedures a clinician needs to perform the procedure independently with reasonable outcome
- Relationship between experience with a new procedure or technique and an outcome variable
  - First stick success rate
  - Dwell time success rate
  - Reduced complication rate
- Improvement in performance over time
- May depend on manual dexterity
- May depend on background knowledge

Raja , R (2024) The impact of the learning curve in laparoscopic surgery, World Laparoscopy Hospital, www.laparoscopyhospital.com

Definition: learning curve business perspective

Mathematical concept[1]

Graphically depicts how a process is improved over time due to learning and increased proficiency

Less material and less time

Business perspective[2]

A curve plotting performance against practice

one graphing decline in unit costs with cumulative output

learning curve is typically described with a percentage that identifies the rate of improvement

[1]What Is a Learning Curve? Formula, Calculation, and Example

[2]Learning curve Definition & Meaning - Merriam-Webster

Learning curve: Novice PIV placement/No US N=6 students/simulator model

3 students

- 26-48 attempts
- 50% criteria success

5 students

- 15-55 attempts
- 25% criteria success

If you lower the success rate the performance improves or does it

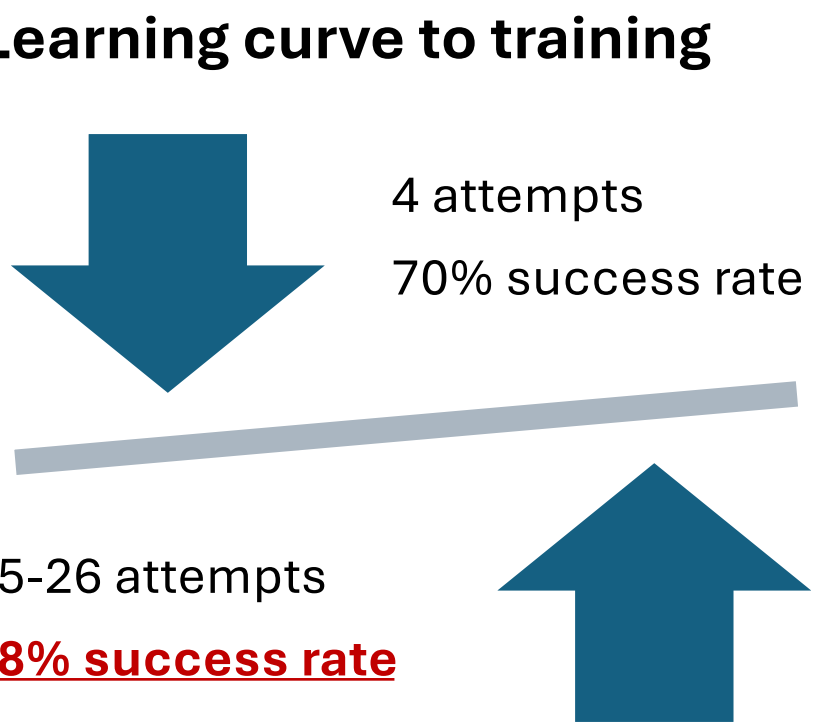
Most difficult to master

1. Advance the catheter and stylet in the vein (38.9% failure)
2. Reduce the angle and advance the stylet 1-2 mm further (55.9% failure)

Campbell RD, Hecker KG, Biau DJ, Pang DSJ (2014) Student Attainment of Proficiency in a Clinical Skill: The Assessment of Individual Learning Curves. PLoS ONE 9(2): e88526. doi:10.1371/journal.pone.0088526

Learning curve USGPIV: Stolz (2016)

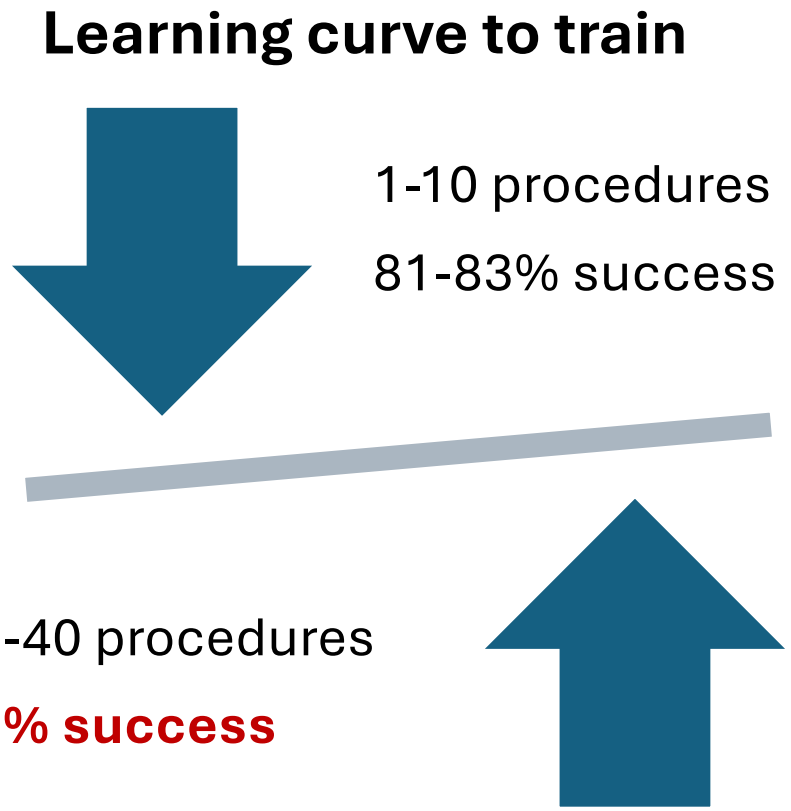
- Prospective/observational
- Emergency room
- Paramedics & RN's
- Already competent at PIV access landmark technique
- 1,077 attempts/797 patients
- 33 healthcare workers trained
- Overall success rate after training 88%
- Success was defined as the ability to aspirate blood and flush saline
- **Proficiency was defined a priori as 70% probability of success.**



Stolz LA, Cappa AR, Minckler MR, Stolz U, Wyatt RG, Binger CW, Amini R, Adhikari S. Prospective evaluation of the learning curve for ultrasound-guided peripheral intravenous catheter placement. J Vasc Access. 2016 Jul 12;17(4):366-70. doi: 10.5301/jva.5000574. Epub 2016 Jun 3. PMID: 27312767.

Learning curve USG PIV: vanLoon (2022)

- Multicenter, prospective, observational study
- 1,885 procedures/49 practitioners
- PACU RN, oncology RN, radiographers
- Qualified in PIV placement with landmark technique
- Successful cannulation was flush without infiltration
- 97% procedural competence



Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Learning curve USG PIV: vanLoon (2022)

Success Rates	Anesthesia N=49	PACU RN N=19	Oncology RN N=11	Radiographers N=10	Overall N=49
1 procedure	48%	26%	41%	37%	40%

Success Rates	Anesthesia N=49	PACU RN N=19	Oncology RN N=11	Radiographers N=10	Overall N=49
All procedures	93%	93%	93%	92%	92%
1-10	81%	82%	82%	83%	81%
11-20	92%	92%	95%	93%	92%
21-30	96%	97%	95%	96%	97%
31-40	98%	98%	98%	98%	98%

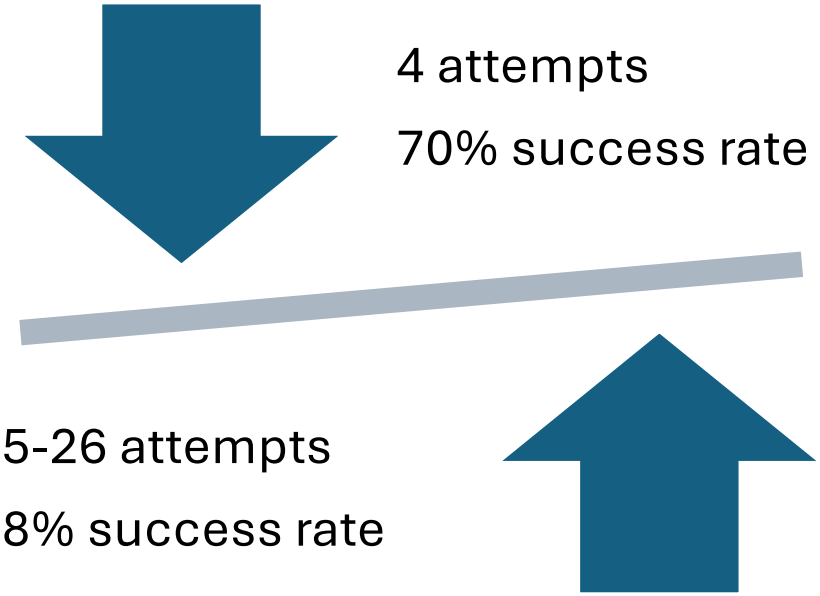
Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Training methodologies Stolz (2016) Loon (2022)

Training USG PIV: Stolz (2016)

- Didactic (2 hour)
  - Optimization of images
  - Image acquisition
  - Method confirm vein vs. artery
  - Step by step procedure
  - Management complications
  - Documentation of the procedure
  - In plane for obtaining venous access
  - Identification of artifact, tissue, nerve
- Practicum
  - Phantom
  - Live models to identify vasculature
  - Live models to identify probe handling and line up long axis of the vein
- Proctoring
  - **5 procedures**
- Outcomes tracked with quality assurance database

Learning curve to training



Minimum proficiency skill set at 70%

Stolz LA, Cappa AR, Minckler MR, Stolz U, Wyatt RG, Binger CW, Amini R, Adhikari S. Prospective evaluation of the learning curve for ultrasound-guided peripheral intravenous catheter placement. J Vasc Access. 2016 Jul 12;17(4):366-70. doi: 10.5301/jva.5000574. Epub 2016 Jun 3. PMID: 27312767.

Training USG PIV 6 weeks: vanLoon (2022)

Didactic

40 Question pre-test knowledge

Reader background theoretical information self study

1 hour face to face training lecture

40 question post-test

Hands on Practicum

10 max per session

Life model veins tracing and identification (30 minutes each)

Short and long axis training

15 USG PIV with phantom (60 minutes)

Data success recorded

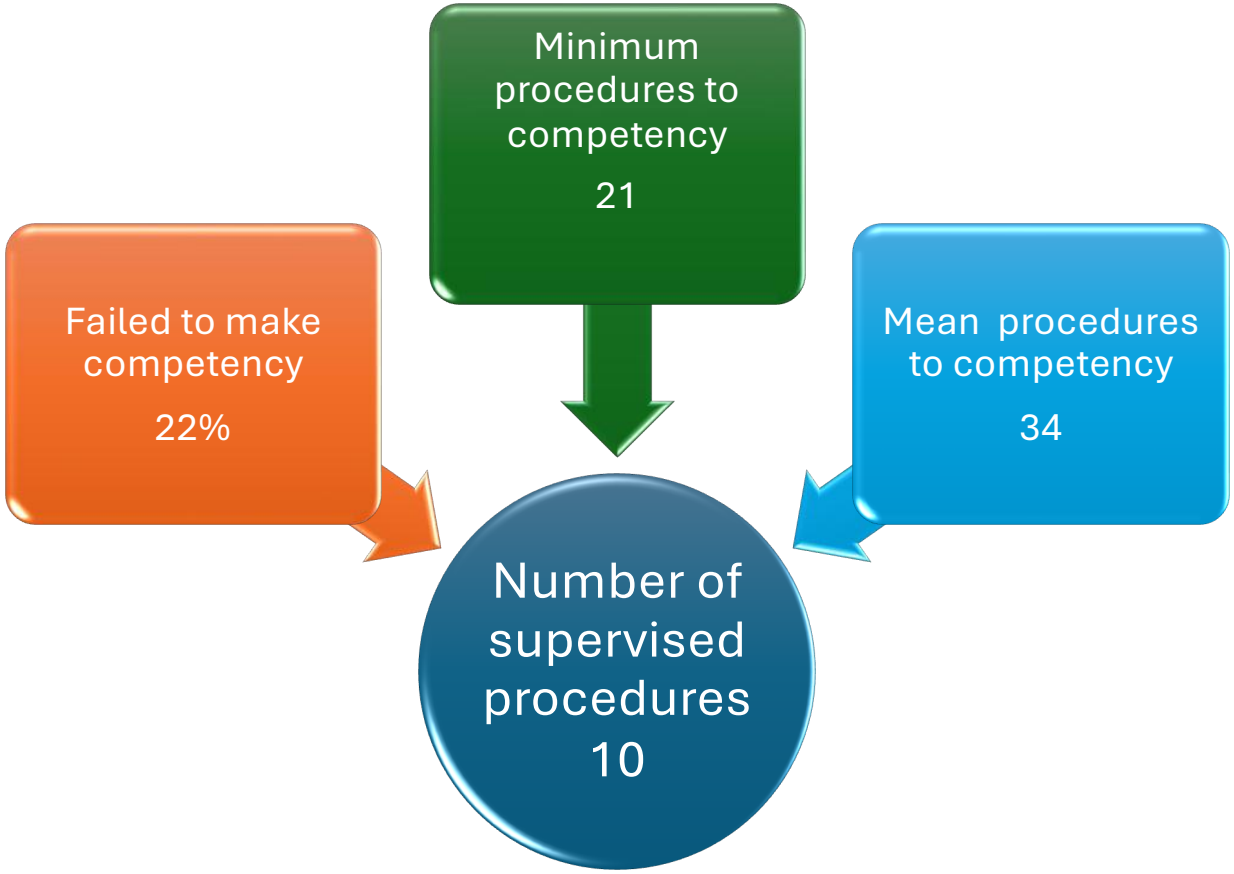
Proctoring

10 procedures/ required to perform 40 altogether and log results

Focus on needle tip tracking, navigating the vein, perfecting probe control, threading the needle in both shallow and deep veins

Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Training USG PIV: vanLoon (2022)



Unanswered questions

If they had more procedures, they may have made competency?

If they had more proctoring they may have made competency?

Can everyone perform this procedure or are some clinicians not able to?

Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Most Difficult to learn vanLoon (2022)

- Hand and eye coordination
- Holding the probe
- Watching the ultrasound monitor

Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Training: Lessons from laparoscopic surgery training

Distribution of training over several days has also been shown to be superior to training in one day	Obtaining feedback for improvement	Playing video games	Lack of knowledge
Simulator models with feedback besides box models	Lack of synchronized movement of the non dominant hand	Difficult hand eye co-ordination	Standardization of equipment combined with incorporation of check lists enhanced learning curve

Raja , R (2024) The impact of the learning curve in laparoscopic surgery, World Laparoscopy Hospital, www.laparoscopyhospital.com

Competency and skill assessment during training and post training

Competence: Components to measure

KNOWLEDGE

SKILLS

BEHAVIOR

JUDGEMENT

ttps://www.healthstream.com/resource/blog/what-is-competence-in-healthcare-(part-i)#:~:text=Competency%20can%20be%20defined%20as,judgment%20in%20a%20clinical%20setting.

Why measure success during training?

- Create training protocols to determine the minimum number of proctored procedures performed before a providers performs independently
- Track progress of new learners
- Identify those that all out of the curve who need additional help
- Some programs may want to target “superusers” who exceed expectations in the skill as their primary placers

Stolz LA, Cappa AR, Minckler MR, Stolz U, Wyatt RG, Binger CW, Amini R, Adhikari S. Prospective evaluation of the learning curve for ultrasound-guided peripheral intravenous catheter placement. J Vasc Access. 2016 Jul 12;17(4):366-70. doi: 10.5301/jva.5000574. Epub 2016 Jun 3. PMID: 27312767.

Controversy: Competency

Should there be a specific number of procedures performed during training?

Ineffective training for vascular access

1

See one

2

Do one

3

Teach one

Training competency: Literature comments

Skills training (laparoscopic surgery) every task should be repeated 30-35 times for maximum benefit[1]

1.Scott DJ, Young WN, Tesfay ST,et al Laparoscopic skills training. Am J Surg 2001 Aug 182(2):137-42

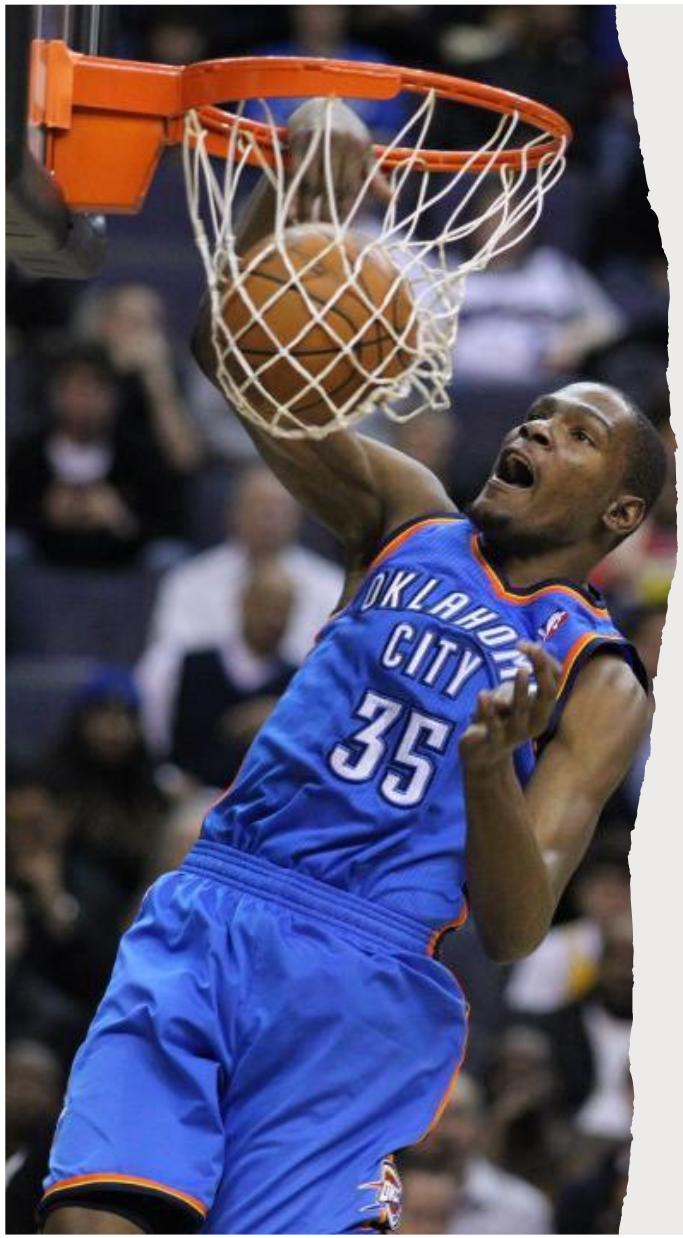
2.Lt.Cmdr. Jesse Ehrenfeld, Public domain, via Wikimedia Commons (picture)

Learning curve: Tsotsolis (2015)

A physician who has performed 50 or more catheterizations is half as likely to result in a mechanical complication as insertion by a physician who has performed <50

Reported that (1) attempt of catheterization the complication rate is 4.3% which rises to 24% in patients who undergo more than two attempts

Tsotsolis N, Tsirgogianni K, Kioumis I, Pitsiou G, Baka S, Papaiwannou A, Karavergou A, Rapti A, Trakada G, Katsikogiannis N, Tsakiridis K, Karapantzos I, Karapantzou C, Barbetakis N, Zissimopoulos A, Kuhajda I, Andjelkovic D, Zarogoulidis K, Zarogoulidis P. Pneumothorax as a complication of central venous catheter insertion. Ann Transl Med. 2015 Mar;3(3):40. doi: 10.3978/j.issn.2305-5839.2015.02.11. PMID: 25815301; PMCID: PMC4356862.



Competency (training): vanLoon (2022) – N=49

21 Minimum procedures

34 Mean procedures

11 (22%) Did not achieve competency

80% gained competency within 34 procedures

97% was defined as procedural competence

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Optimal number procedures in training: Tariq (2015)
Internal Medicine training Survey (N=12 faculty)

Procedure Tariq[1]	Number observe	Number Assist	Number supervised	Number independent	Total
IJ CICC	4	4	5	5	18
Subclavian CICC	4	4	5	5	18
Femoral FICC	2	3	5	5	15

No competency rate was noted

Procedure vanLoon[2]	Number observe	Number assist	Number supervised	Number independent	Total
USG PIV	15 phantom	0	10	30	55

Competency rate set at 97%

Hoskins (2023) meta-analysis cited an average of 5 proctored for competency at 75.5% 1st stick success rate and 1.7 attempts with an overall of 82.5%

[1]Tariq M, Bhulani N, Jafferani A, Naeem Q, Ahsan S, Motiwala A, van Dalen J, Hamid S. Optimum number of procedures required to achieve procedural skills competency in internal medicine residents. BMC Med Educ. 2015 Oct 23;15:179. doi: 10.1186/s12909-015-0457-4. PMID: 26493025; PMCID: PMC4619250.
[2]Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139

Controversy: Competency

Should there be a specific number of procedures performed during training?

YES

I believe we need to establish a number

Controversy: Competency

Should there be a number of procedures performed post training?

Practice makes Perfect: Carlson (2019)

- Competency represents the minimal threshold for skill development while proficiency signifies an element of mastery
- We are aiming for proficiency

Carlson JN, Wang HE. Paramedic Intubation: Does Practice Make Perfect? *Ann Emerg Med.* Sep 2017;70(3):391-393.

Competency and proficiency CVAD: WoCoVa(2013)

- "Only clinicians competent **in CVAD** insertion and maintenance should perform these procedures"
- "Instructors must also demonstrate continued competency and proficiency in CVAD insertion"
- Suggestion
  - ✓Periodic assessment (not just at training)
  - ✓Systematic approach to measure outcomes continuously
  - ✓Method to provide feedback to competence as a function of safety
- A decline in knowledge is associated with a decline in care

Moureau N, Lamperti M, Kelly LJ, Dawson R, Elbarbary M, van Boxtel AJ, Pittiruti M. Evidence-based consensus on the insertion of central venous access devices: definition of minimal requirements for training. Br J Anaesth. 2013 Mar;110(3):347-56. doi: 10.1093/bja/aes499. Epub 2013 Jan 29. PMID: 23361124.

Competency and proficiency: INS (2024)

- “Develop competency through repetitive practice until the skill can be successfully performed on patients under supervision”
- “Measure competency by performance and not by a time of predetermined numbers of procedures performed that will ensure competency for the skill”
- “Success rates with USG-PIV and or CVAD insertions have been shown to improve with the greater number of procedures performed”

Nickel B, Gorski L, Kleidon T, Kyes A, DeVries M, Keogh S, Meyer B, Sarver MJ, Crickman R, Ong J, Clare S, Hagle ME. Infusion Therapy Standards of Practice, 9th Edition. J Infus Nurs. 2024 Jan-Feb 01;47(1S Suppl 1):S1-S285. doi: 10.1097/NAN.0000000000000532. PMID: 38211609.

Competency and proficiency: INS (2024)

Clinician competency measures

Vascular visualization technology

- ✓Assessment of vessels
  - ✓Size
  - ✓Depth
  - ✓Location
- ✓Potential complications
- ✓Adherence to no touch technique

Assess competency methods

- Self-assessment
- Peer-assisted learning
- Assessment by others (preceptor or instructor)
- Reassess and document competency at least every 12 months (USA)

Nickel B, Gorski L, Kleidon T, Kyes A, DeVries M, Keogh S, Meyer B, Sarver MJ, Crickman R, Ong J, Clare S, Hagle ME. Infusion Therapy Standards of Practice, 9th Edition. J Infus Nurs. 2024 Jan-Feb 01;47(1S Suppl 1):S1-S285. doi: 10.1097/NAN.0000000000000532. PMID: 38211609.

Competency: WoCoVa (2013) and INS (2024)

Competency	INS PIV and CVAD (2024)[2]	WoCoVa CVAD (2013)[1]
Competency assessment	Once a year (USA)	Periodic assessment
Outcome measurement tool	Yes	Yes
Recommendation for method for feedback	Yes	Yes
Number of procedures	Not cited	Not cited

[1]Moureau N, Lamperti M, Kelly LJ, Dawson R, Elbarbary M, van Boxtel AJ, Pittiruti M. Evidence-based consensus on the insertion of central venous access devices: definition of minimal requirements for training. Br J Anaesth. 2013 Mar;110(3):347-56. doi: 10.1093/bja/aes499. Epub 2013 Jan 29. PMID: 23361124.
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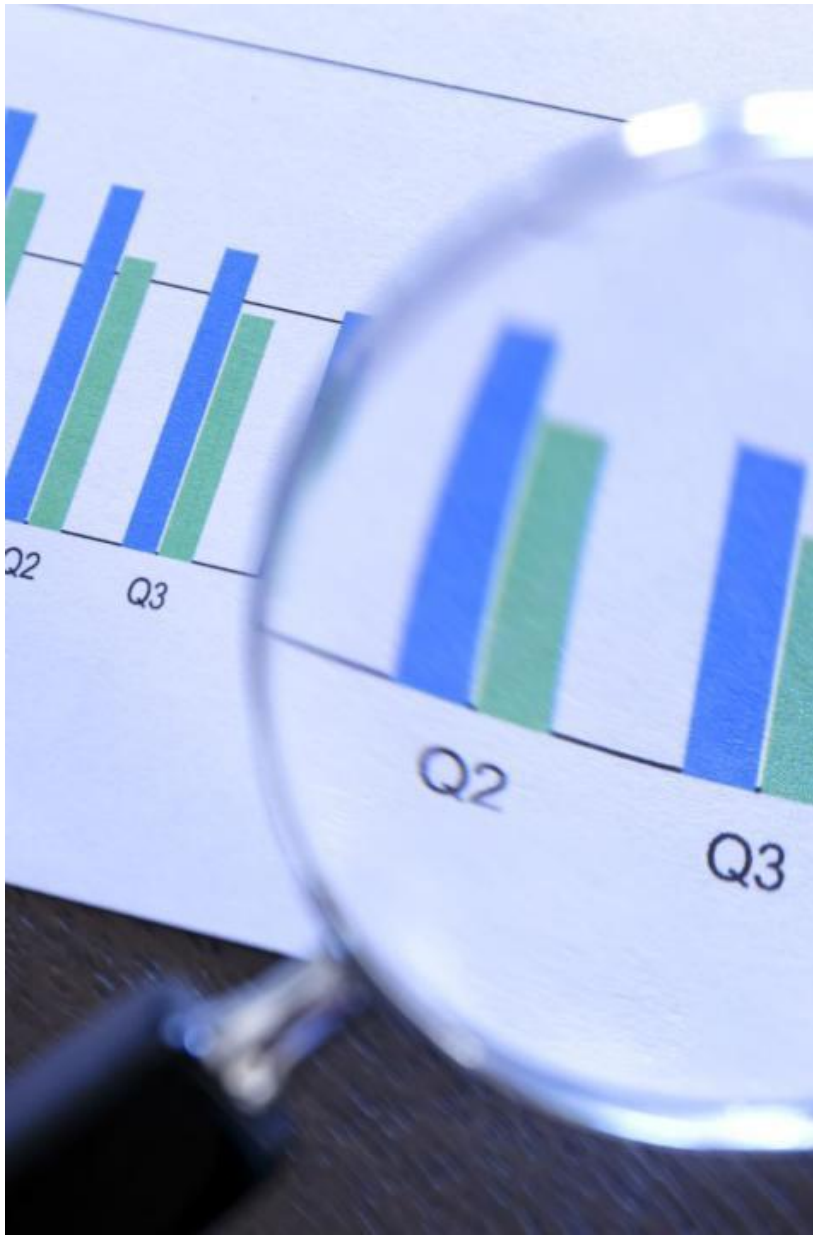
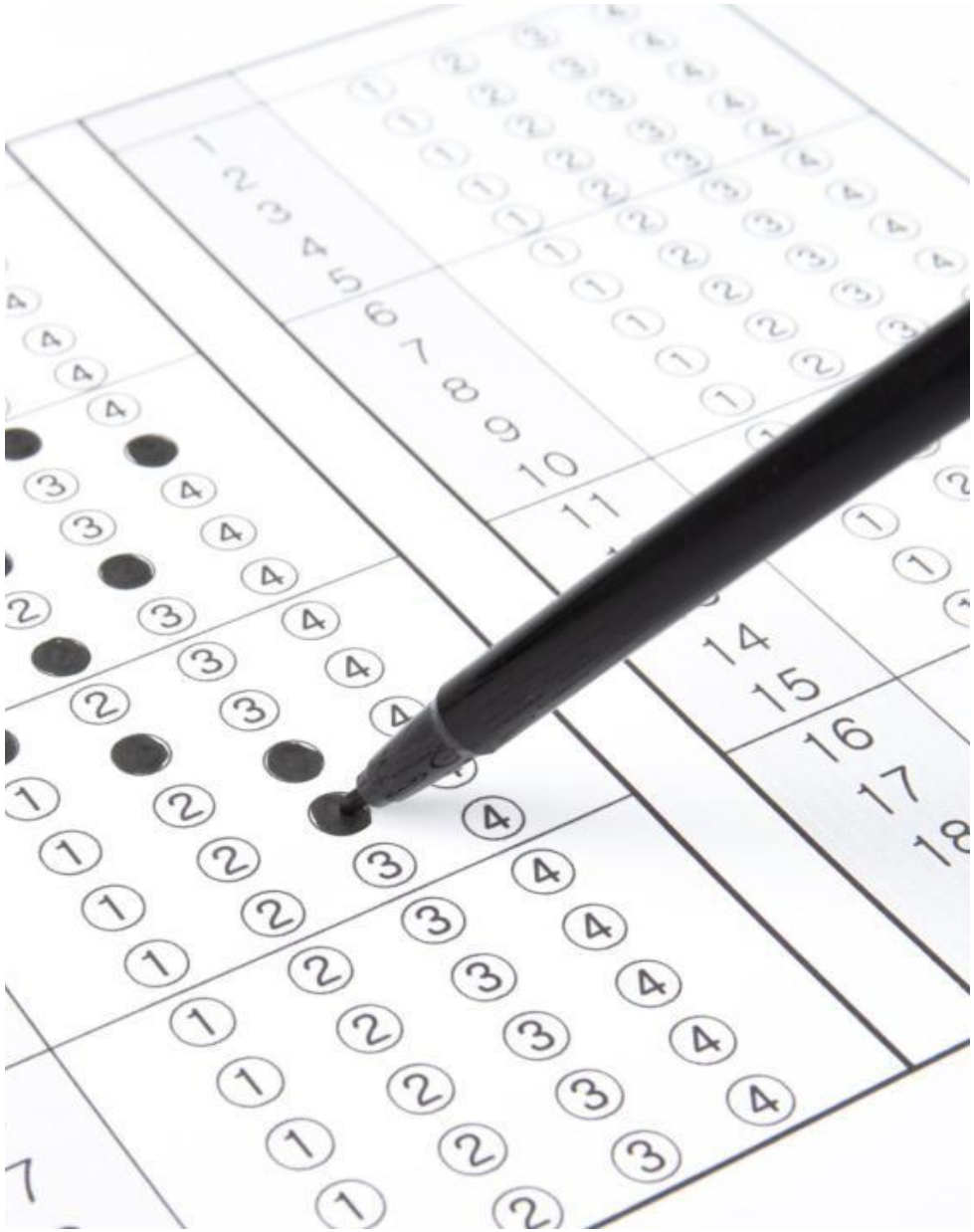


Proficiency: Post learning curve

- No guidelines indicate a minimum number of procedures a year
- Reeves (2017) suggested that 3 procedures be performed successfully a month for ongoing competency

Proposed training:
Summation
Common elements
Hoskins (2023)
Systematic review and common core elements (35 studies)

Hoskins MJ, Nolan BC, Evans KL, Phillips B. Educating health professionals in ultrasound guided peripheral intravenous cannulation: A systematic review of teaching methods, competence assessment, and patient outcomes. Medicine (Baltimore). 2023 Apr 21;102(16):e33624. doi: 10.1097/MD.0000000000033624. PMID: 37083799; PMCID: PMC10118335.



Training: Testing (vanLoon 2022)

- 40 question pre test
- 40 question post test

Loon FHV, Scholten HJ, Korsten HH, Dierick-van Daele AT, Bouwman AR. The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study. Med Ultrason. 2022 May 25;24(2):188-195. doi: 10.11152/mu-3322. Epub 2022 Jan 11. PMID: 35045139.

Training: References

O'Dochartartaigh D (2019): Ultrasound guided peripheral intravenous catheter placement learning module, Covenant Health, Albertan Health Services

Moureau N, Lamperti M, Kelly LJ, Dawson R, Elbarbary M, van Boxtel AJ, Pittiruti M. Evidence-based consensus on the insertion of central venous access devices: definition of minimal requirements for training. Br J Anaesth. 2013 Mar;110(3):347-56. doi: 10.1093/bja/aes499. Epub 2013 Jan 29. PMID: 23361124.

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Training: Theoretical core elements

- ✓ Anatomy and physiology related to ultrasound
  - Veins, arteries, nerve bundles, blood flow, tip location
- ✓ Vein assessment and selection
  - Upper and lower extremity, vessel size, depth
- ✓ Contraindications
  - Burns, traumatic injuries, AV fistulas, DVT limb, skin infections etc.
- ✓ Device selections in accordance with guidelines and standards
- ✓ Complications and complication management
  - Arterial puncture, hematoma, infection, phlebitis, extravasation, infiltration, nerve damage, thrombophlebitis
- ✓ Care & maintenance & documentation
- ✓ Insertion technique with infection prevention methodology

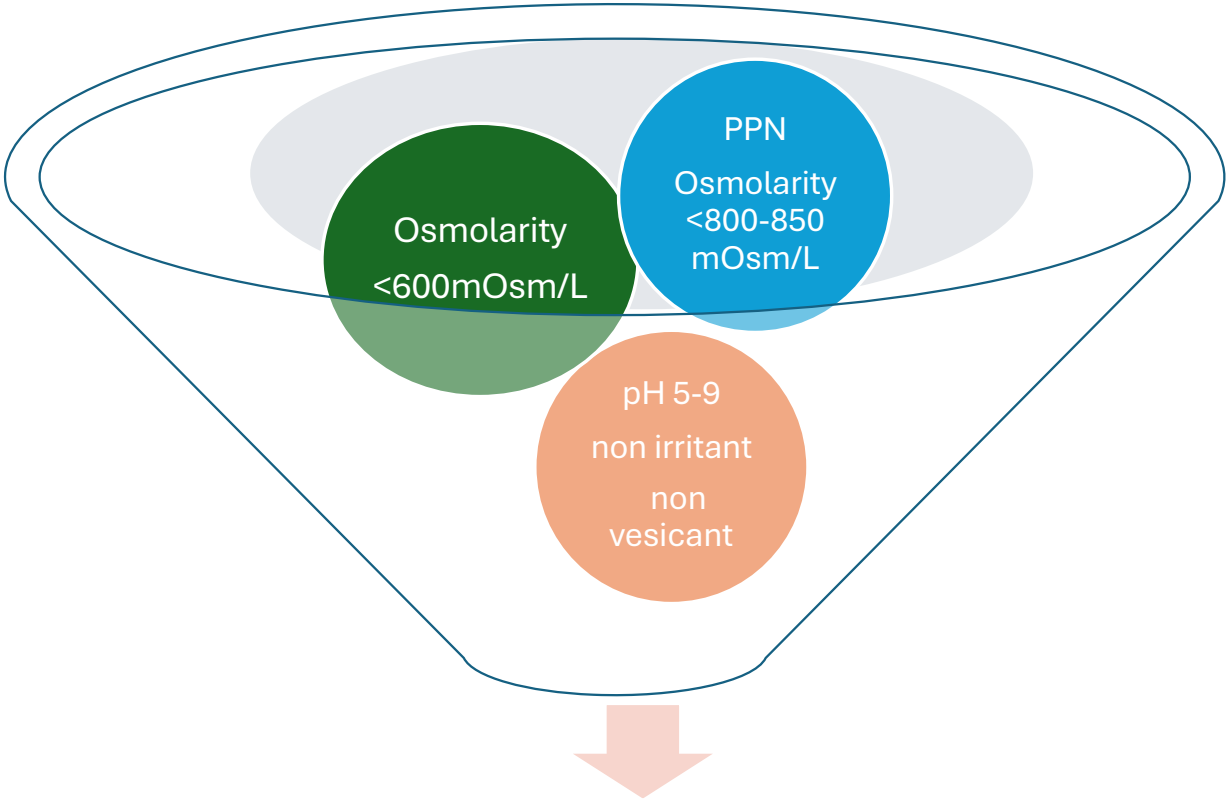
Manual

Online

Video

Classroom

Hoskins (2023) meta-analysis average 2.5 hours with a range of 1.5-91.5 hours



ERPIUP guidelines DAV
Expert GAVeCeLT

Points to consider training: Guidelines

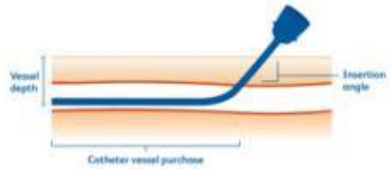
Pittiruti M, Van Boxtel T, Scoppettuolo G, et al. European recommendations on the proper indication and use of peripheral venous access devices (the ERPIUP consensus): A WoCoVA project. The Journal of Vascular Access. June 2021.doi:10.1177/11297298211023274

Choice of device for venous access | VAD Expert

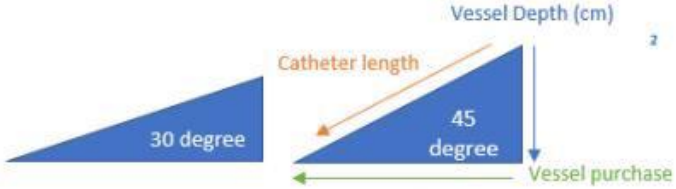
Vessel Purchase

How to determine how much catheter will reside in vessel

- Depth of vessel in tissue
- Insertion angle
- Catheter length



Example:



Understanding Vessel Purchase in Peripheral Catheters (cont'd.)

Vessel depth (cm)	Insertion angle (°)	Catheter length	Catheter vessel purchase (in.)	% Catheter in vessel
0.5	30	1 in.	0.6	61%
		1.25 in.	0.9	69%
		1.88 in.	1.5	79%
		2.25 in.	1.9	83%
		8 cm (3.15 in.)	2.7	88%
		10 cm (3.94 in.)	3.5	90%
	45	1 in.	0.7	72%
		1.25 in.	1.0	78%
		1.88 in.	1.6	85%
		2.25 in.	2.0	88%
		8 cm (3.15 in.)	2.8	91%
		10 cm (3.94 in.)	3.6	93%
1	30	1 in.	0.2	22%
		1.25 in.	0.5	38%
		1.88 in.	1.1	59%
		2.25 in.	1.5	65%
		8 cm (3.15 in.)	2.3	75%
		10 cm (3.94 in.)	3.1	80%
	45	1 in.	0.4	45%
		1.25 in.	0.7	56%
		1.88 in.	1.3	71%
		2.25 in.	1.7	75%
		8 cm (3.15 in.)	2.6	82%
		10 cm (3.94 in.)	3.3	86%
1.5	30	1 in.	-0.2	-17%
		1.25 in.	0.1	6%
		1.88 in.	0.7	38%
		2.25 in.	1.1	48%
		8 cm (3.15 in.)	2.0	63%
		10 cm (3.94 in.)	2.7	70%
	45	1 in.	0.2	17%
		1.25 in.	0.4	34%
		1.88 in.	1.1	56%
		2.25 in.	1.4	63%
		8 cm (3.15 in.)	2.3	73%
		10 cm (3.94 in.)	3.1	79%
2	30	1 in.	-0.6	-56%
		1.25 in.	-0.3	-25%
		1.88 in.	0.3	17%
		2.25 in.	0.7	31%
		8 cm (3.15 in.)	1.6	50%
		10 cm (3.94 in.)	2.3	60%
	45	1 in.	-0.1	-10%
		1.25 in.	0.1	12%
		1.88 in.	0.8	41%
		2.25 in.	1.1	51%
		8 cm (3.15 in.)	2.0	65%
		10 cm (3.94 in.)	2.8	72%

The greater the vessel depth the longer the catheter you need to achieve 66% of the catheter in the vessel compared

10 CM length achieves this even at a vein depth of 2 cm

Angle of entry changes your vessel purchase with wider angles needing longer catheters

Training: Simulation laboratory

- Physics of ultrasound and knobology
- Patient and clinical positioning
- Probe selection with cleaning and care post insertion
- Ultrasound image
  - Optimization and analysis,
- Vein assessment and selection
  - Upper and lower extremity, vessel size, depth, identification of artifact, tissue and nerves, identification of vein and artery
- Procedural steps and equipment
  - Placement angle, depth of vein, vessel purchase, tracking the needle tip, visualization of cannula
- Approach
  - In of plane (long-axis) approach (longitudal approach) or out of plane (short axis) approach (transverse approach)

Phantom

Chicken beast

Live model

Live scanning models

Instructor

Video recorded simulation

Hoskins (2023) Classroom was 1:1 or 3:1 or mass groups no consistency

Training: Proctoring on patients with preceptor

Number of studies cited	Number successful proctored in Hoskins (2023) meta-analysis
1	1 successful insertions
5	3 successful insertions
7	10 successful insertions
1	30 successful insertions
Total	N=22

Checklist

3 studies

Standardized supplies

Log book

Out of 34 studies not one mentions observations in field

Reeves (2017) suggested that 3 procedures be performed successfully a month for ongoing competency

INS (2024)

"Consider establishing a mastery learning process for simulation and insertion training that allows the learner to repeat training steps if the mastery rating score is less than a level established by institutional policy"

Nickel B, Gorski L, Kleidon T, Kyes A, DeVries M, Keogh S, Meyer B, Sarver MJ, Crickman R, Ong J, Clare S, Hagle ME. Infusion Therapy Standards of Practice, 9th Edition. J Infus Nurs. 2024 Jan-Feb 01;47(1S Suppl 1):S1-S285. doi: 10.1097/NAN.0000000000000532. PMID: 38211609.

Who should be trained?

Attrition: Stuckey[1] (2019)

5 RN's started

1 hour didactic

1 hour phantom practicum

Post test score 80%

2 RN's finished

10 proctored procedures

83% success rate

Gerbil wheel of training[2]

60% attrition rate

Personal reasons, too much commitment, one placed 3 proctored

[1]Stuckey C, Curtis MP. Development of a nurse-led ultrasound-guided peripheral intravenous program. J Vasc Nurs. 2019 Dec;37(4):246-249. doi: 10.1016/j.jvn.2019.07.003. Epub 2019 Nov 29. PMID: 31847978.

[2]PenyulapAnna Frodesiak, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

What training?

- The higher the competency measure for first stick the greater the number of procedures due to the learning curve for this skill
- To get to >90% first stick success it could take >30 procedures
- Training should include potentially a pre and post test, didactic, practicum skills lab, and proctoring with a possible check-list
- Training can include online modules, workbooks, video, anatomical models, animal models, live subject for scanning, and potentially observations
- The higher the number of proctored live insertions with feedback the higher the success (vanLoon 2022)
- Competency needs periodic assessment post training (INS 2024 suggests yearly) with a measurement tool and outcome monitoring
- No every one is going to master this skill so choose candidates wisely