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Transatlantic Multispecialty Consensus on Fundamental Endovascular Skills: Results of a Delphi Consensus Study☆

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WHAT THIS PAPER ADDS

This paper has identified the key cognitive, technical, and human factor skills necessary to perform endovascular procedures successfully. These fundamental endovascular skills (FES) should be acquired by angiology, interventional radiology, interventional cardiology, and vascular surgery trainees. Inter-specialty differences and dissimilarities between European and American interventionalists are discussed. The challenges of training for these skills in the current clinical education system are considered.

Objectives: The aim of this study was to establish a consensus on Fundamental Endovascular Skills (FES) for educational purposes and development of training curricula for endovascular procedures. The term "Fundamental Endovascular Skills" is widely used; however, the current literature does not explicitly describe what skills are included in this concept. Endovascular interventions are performed by several specialties that may have opposing perspectives on these skills.

Methods: A two round Delphi questionnaire approach was used. Experts from interventional cardiology, interventional radiology, and vascular surgery from the United States and Europe were invited to participate. An electronic questionnaire was generated by endovascular therapists with an appropriate educational background but who would not participate in subsequent rounds. The questionnaire consisted of 50 statements describing knowledge, technical, and behavioral skills during endovascular procedures. Experts received the questionnaires by email. They were asked to rate the importance of each skill on a Likert scale from 1 to 5. A statement was considered fundamental when more than 90% of the experts rated it 4 or 5 out of 5.

Results: Twenty-three of 53 experts invited agreed to participate: six interventional radiologists (2 USA, 4 Europe), 10 vascular surgeons (4 USA, 6 Europe), and seven interventional cardiologists (4 USA, 3 Europe). There was a 100% response rate in the first round and 87% in the second round. Results showed excellent consensus among responders (Cronbach's alpha = .95 first round; .93 second round). Ninety percent of all proposed skills were considered fundamental. The most critical skills were determined.

Conclusions: A transatlantic multispecialty consensus was achieved about the content of "FES" among interventional radiologists, interventional cardiologists, and vascular surgeons from Europe and the United States. These results can serve as directive principles for developing endovascular training curricula.

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INTRODUCTION

Endovascular procedures have become the standard treatment of care for several patients with symptomatic cardiac and vascular disease.[1–4] As a result, endovascular skills' training programs are increasingly required. Knowing the various endovascular tools, technical skills that are different from open surgery, appropriate decision making, and communication are essential to treat patients safely by endovascular means.[5,6]

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The current literature does not define these key skills.[7] Furthermore, interventional cardiologists, interventional radiologists, and vascular surgeons perform endovascular interventions while considering different endovascular skills to be fundamental.

The objective of this research was to identify the key skills that should be achieved in a Fundamental Endovascular Skills (FES) program, based upon the opinion of a panel of experts in endovascular procedures (interventional cardiology, interventional radiology, and vascular surgery) using responses to serial questionnaires according to a modified Delphi technique. This approach has previously been used in an international expert consensus on a framework for a simulation based surgical training curriculum,[8] to define principles for developing a radiology curriculum,[9] to provide guidelines for training and assessment of non-technical skills,[10] and to define the key steps for a standardized laparoscopic curriculum.[11] A multispecialty consensus concerning competence assessment,[12] case selection prior to carotid artery stenting,[13] and patient management have also been achieved using this modified Delphi technique.[14–17]

Defining FES may enable endovascular specialists to create and provide a common educational ground for endovascular training. The results of this study may not only influence tutors but may also guide program directors, healthcare institutions, and policy makers to improve patient safety by acquiring fundamental knowledge and technical skills before approaching actual patients. Key skills can be assessed to certify that an endovascular specialist has the FES before being enrolled in any advanced endovascular training program.[18] Finally, device manufacturers and simulation companies may use these fundamental skills to guide the design of their training modules.

MATERIALS AND METHODS

Study design

The Delphi technique is an approach used to gain consensus among a panel of experts.[19] Delphi consensus methodology was used because this technique is characterized by anonymity of the panel ensuring that each participant has an equal possibility to provide and change their opinion in the course of the process.[20] The standard Delphi technique is a structured and interactive communication forecasting method that relies on the opinion of an expert panel.[21] Participants evaluate statements and further re-evaluate these statements in subsequent Delphi rounds based upon anonymous group responses until consensus has been reached.[20] E-mailed questionnaires were used to avoid face to face interactions in order to eliminate undue influence from individuals. Written consent was obtained from all participants by e-mail. The study was set up to permit an initial design of two rounds, with further rounds as required, depending on the level of consensus achieved following analysis of data from the second round.

Questionnaires

Electronic questionnaires providing multiple statements were designed. The questionnaire was based on the endovascular literature, the knowledge, skills, and attitude framework for surgical training.[22] It was finalized after a thorough discussion among four attending physicians experienced in endovascular treatment and/or educational research (R.A., S.M., F.V., and I.V.H.). None of these individuals participated in the subsequent rounds.

The questionnaire consisted of 50 statements describing the three main skills required during endovascular procedures: *knowledge, technical skills*, and *attitudes* concerning peri-operative functioning and communication. Participants were asked to rate the importance of these statements using a 1–5 Likert scale.

Experts

Interventional cardiology and angiology, interventional radiology, and vascular surgery experts from the United States and Europe were invited to participate. These experts were asked to collaborate on a voluntary basis and were eligible if they performed more than 100 peripheral endovascular procedures yearly as the primary operator and were involved in training junior colleagues. It is commonly accepted that the minimum requirement in a Delphi consensus is 5–10 participants from each professional group.[21]

Data analysis

The level of participants' agreement to the statement was drafted on a five point Likert scale comprising "Strongly disagree", "Disagree", "Neutral", "Agree", and "Strongly agree". Skills rated 4 (agree) or 5 (strongly agree) on the five point Likert scale were considered to be FES that should be included in an endovascular training program. In previous Delphi studies, consensus was mostly defined as more than 80% of the experts supporting an element.[23,24]

The first round was sent out to the experts who agreed to participate on March 17, 2014. A 4 week answering period was provided, during which a reminder was sent at 2 week intervals to non-responders. Similarly, the second round was sent out to the same group of experts on May 5, 2014. The questionnaire consisted of the same statements providing the distributions of scores (mean score and standard deviation) for each question from the first round. In the second round, the experts were instructed to reconsider the statements presented in the first round.

For statistical analysis SPSS 22.0 (Statistical Package for the Social Sciences, IBM Company, Armonk, NY, USA) was used. The Cronbach alpha test was used to determine the internal consistency in the first and second round of the Delphi survey. The results were analyzed using non-parametric tests. Wilcoxon signed ranks test was used to compare ratings of the elements between the first and second round. To compare groups for differences between specialties and nationalities the Kruskal–Wallis test was used. A sensitivity analysis was performed to determine the

robustness of the results. The results of rounds 1 and 2 were compared for only those participants who rated both rounds ($N = 20$, Cronbach's alpha $= .96$). To determine the ranking of the statements, mean values of the experts' ratings were used.

RESULTS

Twenty-three of the 53 (43%) invited experts agreed to participate in the survey. The panel consisted of six interventional radiologists (2 USA, 4 Europe), 10 vascular surgeons (4 USA, 6 Europe), and seven interventional cardiologists and angiologists (4 USA, 3 Europe). Three experts performed between 100 and 200 procedures each year (1 interventional radiologist, 2 vascular surgeons). The majority (12 experts) performed between 200 and 500 procedures yearly (3 interventional radiologists, 4 interventional cardiologists, 5 vascular surgeons). Seven performed between 500 and 1,000 procedures on a yearly basis (2 interventional radiologists, 2 interventional cardiologists, 3 vascular surgeons), and one interventional cardiologist performed more than 1,000 procedures each year. Thirteen experts were currently working in a teaching hospital, nine experts in an academic setting, and one expert in a non-teaching clinic. The number of responses in rounds one and two were respectively 23 (100%) and 20 (87%). When submitted, full responses to all questions were received. In this survey, the group was very positively skewed; therefore a statement was considered a FES when more than 90% of the experts rated it 4 or 5 out of 5.

Consensus was achieved in 90% of the discussion subjects. There was a strong internal consistency among the experts in both rounds (Cronbach's alpha $= .95$ first round; Cronbach's alpha $= .93$ second round).

The panel agreed that all statements concerning *knowledge* should be included in an endovascular curriculum, except for the principles of radiation safety and ALARA (*As Low as Reasonably Achievable*) principles. The top five most

Table 1. Statements rated differently between the two Delphi rounds across specialties.

Statement	Interventional radiology, Mean (SD) ($N = 6$)	Interventional cardiology, Mean (SD) ($N = 7$)	Vascular surgery, Mean (SD) ($N = 10$)	*p*
Select an appropriate access site and approach (i.e. retrograde, antegrade)				
Round 1	4.17 (0.41)	4.86 (0.38)	4.90 (0.32)	**.006**
Round 2	4.83 (0.41)	5.00 (0.00)	4.89 (0.33)	.663
Feed the working catheter over the guide wire to the appropriate level i.e. catheter does not pass beyond the tip of the guide wire				
Round 1	4.17 (0.41)	4.86 (0.38)	4.90 (0.32)	**.006**
Round 2	4.67 (0.52)	5.00 (0.00)	4.89 (0.33)	.295
Insert balloon catheter across lesion while keeping guide wire steady				
Round 1	4.01 (0.63)	4.86 (0.38)	4.60 (0.69)	**.040**
Round 2	4.50 (0.55)	5.00 (0.00)	4.67 (0.50)	.205
Choose and prepare appropriate supportive (working) catheter				
Round 1	3.83 (0.75)	5.00 (0.00)	4.60 (0.52)	**.007**
Round 2	4.17 (0.75)	4.60 (0.55)	4.67 (0.71)	.292
Use fluoroscopy guidance during balloon angioplasty				
Round 1	4.33 (0.52)	5.00 (0.00)	4.80 (0.42)	**.024**
Round 2	4.50 (0.55)	5.00 (0.00)	4.67 (0.50)	.205
Decompress balloon fully before repositioning or removal				
Round 1	4.17 (0.41)	5.00 (0.00)	4.90 (0.32)	**.001**
Round 2	4.50 (0.55)	4.80 (0.45)	4.78 (0.44)	.459
Navigate guide wire supported by working catheter using road map to cross the lesion				
Round 1	4.17 (0.41)	4.86 (0.38)	4.60 (0.52)	**.048**
Round 2	4.50 (0.55)	4.80 (0.45)	4.67 (0.71)	.546
Check patient records (blood results, medication) prior to start the procedure				
Round 1	4.17 (0.98)	5.00 (0.00)	4.20 (0.63)	**.030**
Round 2	4.67 (0.52)	5.00 (0.00)	4.67 (0.50)	.348
Give briefing to endovascular team (anesthetist, nurses) prior to start the procedure				
Round 1	4.50 (0.55)	5.00 (0.00)	5.00 (0.00)	**.009**
Round 2	4.50 (0.55)	4.60 (0.89)	4.78 (0.44)	.552
Proper and safe positioning of patient on table in angiosuite				
Round 1	4.50 (0.55)	5.00 (0.00)	5.00 (0.00)	**.009**
Round 2	4.83 (0.41)	5.00 (0.00)	4.78 (0.44)	.549
Ensure the side is marked prior to start the procedure				
Round 1	4.33 (0.52)	5.00 (0.00)	4.60 (0.52)	**.044**
Round 2	4.33 (0.52)	5.00 (0.00)	4.67 (0.71)	.079
Insert stent if appropriate (type, length and size) across lesion, keeping wire steady				
Round 1	4.17 (0.75)	4.86 (0.38)	4.70 (0.48)	.108
Round 2	4.00 (0.89)	5.00 (0.00)	4.78 (0.44)	**.037**

Note. Statistically significant values are in bold.

important FES for knowledge are "Knowledge of the vascular anatomy", "Benefits and limitations of endovascular procedures", "Knowledge of indications for open and endovascular treatments", "Risk associated with various procedural phases", and "Interpretation of the imaging findings (normal and pathological)".

Twenty-four of the 26 *technical skills* were considered fundamental skills. The top three FES in terms of technical performance were "Select an appropriate access site and approach (i.e. retrograde, antegrade)", "Insert selected guide wire correctly to appropriate level with proper care for obstruction, side branches and vessel trauma", and "Evaluate the lesion and run -off (if unknown) prior to treat lesion". In contrast, "Administration of the accurate dose of heparin" and "Performing an angiogram to check the lesion after angioplasty in multiple projections" were not considered fundamental among the experts. Only "Administration of the accurate dose of heparin" and "Performing an angiogram to check the lesion after angioplasty in multiple projections" were not included.

Twelve of 14 *attitudes* were scored highly by the participants. The top three FES for attitude are "Know own limitations and call for help from is/her supervisor", "Check patient records (blood results, medication,) prior to start the procedure", "Check informed consent that has been obtained prior to start the procedure in the angio suite". "Ensuring the endovascular team is wearing radioprotective clothing" and "Ensuring the side is marked prior to start the procedure" were not considered to be FES. The overall responses to the questions in both rounds are shown in Appendix 1. The statements are organized according to level of importance, based upon the mean score of the experts.

Considering both fundamental and non-fundamental skills, a statistically significant difference was found between the three participating specialties in 12 of 50 questions (Table 1). Only one of the non-fundamental skills was rated differently between the specialties: "Ensuring the side is marked prior to start the procedure". However, this significant difference in rating of this statement was only noted in the first round (4.33 Radiology vs. 5.00 Cardiology vs. 4.60 Surgery; $p = .044$).

On the other hand, significant differences were noticed between experts from Europe and the United States for five skills (Table 2). European physicians tended to rate the importance of these statements higher than colleagues from the United States. One of the non-fundamental skills was rated differently across continents: "Performing an angiogram to check the lesion after angioplasty in multiple projections". During the first Delphi round there was no significant difference, however during the second survey physicians from the United States rated this skill significantly lower than physicians from Europe (4.25 United States vs. 4.92 Europe; $p = .011$).

Statistically significant differences between ratings in the first and second Delphi round were found for three statements: "Select an appropriate access site and approach (i.e. retrograde, antegrade)" (4.52 vs. 4.90; $p = .025$), "Feed the working catheter over the guide wire to the appropriate level, i.e. catheter does not pass beyond the tip of the guide wire" (4.48 vs. 4.70; $p = .046$) and "Check patient records (blood results, medication) prior to start the procedure" (4.53 vs. 4.75; $p = .033$).

Table 2. Statements rated differently between the two Delphi rounds across nationalities.

Statement	Europe ($N = 13$)	USA ($N = 10$)	p
Check informed consent that has been obtained prior to start the procedure in angiosuite			
Round 1	4.54 (0.78)	3.50 (1.18)	**.028**
Round 2	4.42 (0.52)	3.50 (0.96)	**.019**
Communicate effectively with patient			
Round 1	4.54 (0.52)	3.80 (0.92)	**.042**
Round 2	4.33 (0.49)	4.12 (0.64)	.461
Knowledge of optimal medical treatment of peripheral arterial disease			
Round 1	4.54 (0.52)	4.90 (0.32)	.068
Round 2	4.92 (0.29)	4.12 (1.36)	**.036**
Check intraluminal position of the catheter after crossing lesion with contrast			
Round 1	4.77 (0.44)	4.80 (0.42)	.862
Round 2	5.00 (0.00)	4.62 (0.52)	.025
Perform angiogram in multiple projections to evaluate lesion after angioplasty			
Round 1	4.77 (0.44)	4.80 (0.42)	.862
Round 2	4.92 (0.29)	4.25 (0.71)	**.011**

Note. Statistically significant values are in bold.

To determine the impact of the 20 experts only responding to both Delphi rounds, a sensitivity analysis was performed, showing consistent results when analyzing only the data of experts who responded to both rounds.

DISCUSSION

Endovascular procedures to treat cardiovascular disease are increasingly used and require specific core skills to treat patients safely and obtain good outcomes. The present study has explored what cognitive skills, technical skills, and attitudes are considered fundamental during endovascular procedures using the Delphi technique. In two rounds a transatlantic multispecialty consensus was achieved on what skills should be included in every basic endovascular training curriculum. It should be noted there was almost always an increase in ratings from the first to the second round, but these skills were already rated important in the first round. These high ratings reveal the importance of implementing these skills in endovascular training curricula. Based upon the expert ratings, the most important skills could be determined for each of the three categories.

Fundamental knowledge skills

For every endovascular specialist, independent of their specialty, the top five most important FES for *knowledge* implementation are to be actively involved in the outpatient clinic to see and evaluate cardiovascular patients, be able to initiate or optimize medical treatment, and to decide what type of treatment is indicated per individual patient. Likewise, each endovascular team member should

know the imaging facilities and the endovascular tool kit that is routinely used in the angiosuite or operating room.

On the other hand, "The principles of radiation safety and ALARA principles" were not considered to be fundamental. This is no surprise since Bordoli et al.[25] have suggested that there might be a lack of formal radiation safety training in the United States for vascular surgery residents. In some countries a radiology technician is present during every endovascular intervention to adjust the C-arm, to use the aortic pump, but also to ensure that each team member is protected by wearing lead aprons. Therefore, these interventionalists might not consider radiation safety as a fundamental knowledge skill because it is the responsibility of the radiology technician. However, in the literature there is sufficient evidence that operator controlled imaging significantly reduces radiation exposure, for example during endovascular aneurysm repair.[26–28] Furthermore, radiation education has been shown to be effective in reducing radiation exposure[29] and recommendations for basic knowledge training of X-ray physics and image production were defined. Software is continuously being developed and improved and with the routine use of fusion in the hybrid angiosuite the exposure of patients and operators to radiation is significantly reduced. The use of roadmap to cross the lesion can be replaced by overlaying a reference image obtained from a digital subtraction angiogram (DSA) run. This does not confer any additional radiation whereas the roadmap uses high radiation; moreover it may even decrease exposure to the operators since the DSA can be obtained with a power injector while the operator is away from the radiation source. Worldwide there is increasing attention to improving radiation safety by demanding that personnel using any radiation equipment have to obtain a certificate proving that they know the ALARA principles.[30]

Fundamental technical skills

The top three principles of technical performance are the key to success in any endovascular procedure, for example in an occlusion of the popliteal artery an ipsilateral antegrade approach is preferred and in obese patients retrograde contralateral femoral access might be preferable.

On the other hand, the administration of heparin was considered less important, possibly influenced by the fact that this is a routine step, often initiated and followed up by the anesthesiologist or anesthesiology nurse. *Although evaluation of the results after percutaneous transluminal angioplasty (PTA) in multiple projections is important, especially in complex lesions, this was not considered a basic endovascular skill.* It is not the intention that an endovascular interventionalist becomes a technician, because the primary aim should be to become and remain an excellent clinician. It should be noted that many of the fundamental skills selected, focus on clinical parameters.

Fundamental attitude and behavior skills

The panel agreed that "Ensuring the endovascular team is wearing radio protective clothing" and "Ensuring the side is marked prior to start the procedure" are not FES. Radioprotective clothing focuses again on the importance of radiation safety, thus considered non-fundamental similar to the statements concerning ALARA principles as explained above. Ensuring that the intervention side is marked might be considered as part of the surgical safety checklist and therefore not a specific endovascular skill.[31]

Inter-specialty and inter-continental differences

Interventional radiologists scored the statements systematically lower in the first round; however, based on the median scores of endovascular colleagues they rated the statements higher in the second round, leading to better consensus. Inter-specialty differences had no impact on the decision to consider a skill fundamental or not, since there were no significant differences in the ratings of the specialists in the second round. These statements rated differently across specialties are mostly describing technical skills. This, in contrast to the dissimilarities in ratings across continents, which are mostly statements concerning non-technical skills. European interventionalists seem to find these human factor skills more important.

Limitations

A selection bias cannot be excluded since only 43% (23 of 53) of the invited experts agreed to participate in this study. The survey was possibly too well prepared leaving no room for suggestions or changes by the participants. Since the experts all work in different hospitals, it is possible that their answers are influenced by local traditions besides their specialty.

Despite these limitations, the survey was designed by leaders in the endovascular field with experience in education and highly experienced interventional cardiologists, interventional radiologists and vascular surgeons carrying out peripheral endovascular procedures from both the United States and Europe.

This study has led to the identification of the top five most important FES in terms of *knowledge*, the top three Fundamental endovascular *technical performances*, and the top three fundamental endovascular *attitude skills*. This study is the first report that has attempted to define these skills. The problem now remains how to integrate these FES into daily training programs around the world.

As we all know, insufficient knowledge about endovascular tools and how to cross a lesion safely (fundamental cognitive skill) may lead to vessel perforation and failure. If a trainee is not aware of the patient's history and laboratory results (fundamental attitude skill), uncontrolled bleeding when removing the sheath may cause serious adverse events. The World Health Organization has already successfully addressed some of these issues by the introduction of the surgical safety checklist in the operating room;[32] however, these are not always respected.

How do you train and assess these FES in daily life? Should these skills immediately be learned and practiced on real patients or should these be obtained before treating

real patients, for example using simulation based training with formative feedback. To provide high quality endovascular training programs, a curriculum addressing the fundamental endovascular skills outside of the operating room or angiosuite should be developed and validated. These training programs should be carefully organized in order to avoid a reduction in patient exposure since the implementation of the European Working Time Directive.

CONCLUSION

Specific endovascular skills training is required to improve the quality of care in endovascular treatment. The first step toward training is defining what FES should be achieved in an endovascular training program. Consensus has been reached about the FES that should be taught across various endovascular specialties in the United States and Europe.

The findings can be used to optimize clinical education and to develop structured endovascular training programs including cognitive, technical, and attitude training. Cognitive skills identified by this consensus should be taught and assessed prior to any technical skills and attitude training. Key technical skills may be learnt and practiced using simulation modules prior to learning and practice in real cases.

CONFLICT OF INTEREST

None.

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APPENDIX 1. STATEMENTS DESCRIBING ENDOVASCULAR SKILLS.

Statement	Round 1 ($N = 23$)				Round 2 ($N = 20$)			
	Mean	SD	Median	Consensus	Mean	SD	Median	Consensus
Knowledge skills								
Knowledge of the vascular anatomy	4.91	0.29	5	**100%**	4.75	0.91	5	**95%**
Benefits and limitations of endovascular procedures	4.74	0.45	5	**100%**	4.60	0.94	5	**95%**
Knowledge of indications for open and endovascular treatments	4.89	0.46	5	**96%**	4.60	0.94	5	**95%**
Risk associated with various procedural phases	4.70	0.47	5	**100%**	4.60	0.94	5	**95%**
Interpretation the imaging findings (normal and pathological)	4.87	0.34	5	**100%**	4.60	0.99	5	**90%**
Knowledge and choice of materials, devices and back up tools	4.70	0.47	5	**100%**	4.55	0.99	5	**90%**
Content and use of the general endovascular tool kit	4.65	0.49	5	**100%**	4.50	0.96	5	**95%**
Risk associated with various anatomical zones during the procedure	4.52	0.59	5	**96%**	4.40	0.99	5	**90%**
Knowledge of optimal medical treatment of peripheral arterial disease	4.39	0.72	4	**96%**	4.25	0.97	4	**90%**
Principles of radiation safety and ALARA principles	4.48	0.59	5	**96%**	4.20	1.06	4,5	80%
Statement	Round 1 ($N = 23$)				Round 2 ($N = 20$)			
	Mean	SD	Median	Consensus	Mean	SD	Median	Consensus
Technical skills								
Select an appropriate access site and approach (i.e. retrograde. antegrade)	4.52	0.59	5	**100%**	4.90	0.31	5	**100%**
Insert selected guide wire correctly to appropriate level with proper care for obstruction, side branches and vessel trauma	4.70	0.47	5	**100%**	4.85	0.37	5	**100%**
Evaluate the lesion and run off (if unknown) prior to treat lesion	4.79	0.42	5	**100%**	4.85	0.37	5	**100%**
Insert stent if appropriate (type, length and size) across lesion, keeping wire steady	4.74	0.45	5	**100%**	4.70	0.47	5	**100%**

-continued

Statement	Round 1 ($N = 23$)				Round 2 ($N = 20$)			
	Mean	SD	Median	Consensus	Mean	SD	Median	Consensus
Feed the working catheter over the guide wire to the appropriate level i.e. catheter does not pass beyond the tip of the guide wire	4.48	0.74	5	**96%**	4.70	0.47	5	**100%**
Perform post dilation if appropriate	4.48	0.59	5	**96%**	4.70	0.47	5	**100%**
Remove the balloon over guide wire, leaving wire in place	4.74	0.45	5	**100%**	4.70	0.47	5	**100%**
Check intraluminal position of the catheter after crossing lesion with contrast	4.57	0.66	5	**91%**	4.70	0.47	5	**100%**
Withdraw working catheter, leaving the guide wire in place	4.52	0.66	5	**91%**	4.70	0.47	5	**100%**
Manipulate working catheter to position distal (antegrade puncture) or proximal (retrograde puncture) to the lesion	4.39	0.78	5	83%	4.65	0.49	5	**100%**
Choose appropriate balloon (type, length and size) for angioplasty	4.65	0.49	5	**100%**	4.65	0.59	5	**95%**
Insert balloon catheter across lesion while keeping guide wire steady	4.70	0.48	5	**100%**	4.65	0.59	5	**95%**
Remove stent delivery device over guide wire, leaving guide wire in place	4.57	0.51	5	**100%**	4.65	0.59	5	**95%**
Check run off after angioplasty and/or stenting	4.78	0.42	5	**100%**	4.65	0.59	5	**95%**
Choose and prepare appropriate supportive (working) catheter	4.48	0.59	5	**96%**	4.65	0.59	5	**95%**
Choose and prepare an appropriate initial guide wire - type, diameter, length	4.61	0.58	5	**96%**	4.60	0.68	5	**90%**
Deploy stent according to IFU	4.39	0.72	5	87%	4.55	0.60	5	**95%**
Use fluoroscopy guidance during balloon angioplasty	4.48	0.59	5	**96%**	4.55	0.60	5	**95%**
Inflate balloon with the mechanical inflation device to appropriate pressure for appropriate duration	4.52	0.67	5	**91%**	4.50	0.69	5	**90%**
Decompress balloon fully before repositioning or removal	4.52	0.59	5	**96%**	4.45	0.51	4	**100%**
Use closure devices within IFU or perform manual compression	4.48	0.59	5	**96%**	4.45	0.69	5	**90%**
Navigate guide wire supported by working catheter using road map to cross the lesion	4.39	0.84	5	87%	4.35	0.59	4	**95%**
Administer the accurate dose of heparin	4.26	0.81	4	78%	4.25	0.72	4	85%
US guided puncture of the common femoral artery to obtain access	3.96	0.88	4	70%	4.15	0.50	4	**95%**
Perform angiogram in multiple projections to evaluate lesion after angioplasty	4.17	0.83	4	83%	4.10	0.55	4	**95%**
Perform an angiogram to check lesion after angioplasty in multiple projections	4.39	0.66	4	**91%**	4.10	0.64	4	85%
Statement	Round 1 ($N = 23$)				Round 2 ($N = 20$)			
	Mean	SD	Median	Consensus	Mean	SD	Median	Consensus
Attitude skills								
Know own limitations and call for help from his/her supervisor	4.87	0.34	5	**100%**	4.85	0.36	5	**100%**
Check patient records (blood results, medication) prior to start the procedure	4.53	0.47	5	**100%**	4.75	0.44	5	**100%**
Check informed consent that has been obtained prior to start the procedure in angiosuite	4.43	0.73	5	87%	4.75	0.44	5	**100%**
Communicate effectively with endovascular team members in the angio suite	4.65	0.49	5	**100%**	4.70	0.47	5	**100%**
Communicate effectively with patient	4.87	0.34	5	**100%**	4.65	0.59	5	**95%**
Provide and record clear and appropriate post-intervention instructions	4.65	0.49	5	**100%**	4.65	0.59	5	**95%**

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Statement	Round 1 ($N = 23$)				Round 2 ($N = 20$)			
	Mean	SD	Median	Consensus	Mean	SD	Median	Consensus
Check patient pulses, and color and temperature of the foot at end of the procedure	4.52	0.73	5	**96%**	4.60	0.50	5	**100%**
Function as part of an endovascular team (decision making, coordination)	4.39	0.78	5	83%	4.50	0.51	4,5	**100%**
Give briefing to endovascular team (anesthetist, nurses) prior to start the procedure	4.30	0.82	5	78%	4.35	0.67	4	**90%**
Ensure the endovascular team is wearing radio protective clothing	4.17	0.93	4	74%	4.30	0.73	4	85%
Check materials, equipment and devices with the endovascular team (e.g. US, aortic pump) prior to start the procedure	4.21	0.80	4	78%	4.25	0.55	4	**95%**
Proper and safe positioning of patient on table in angiosuite	4.21	0.79	4	78%	4.10	0.45	4	**95%**
Use assistant to the best advantage at all times	4.21	0.75	4	83%	4.05	0.40	4	**95%**
Ensure the side is marked prior to start the procedure	4.09	1.08	5	65%	4.05	0.83	4	80%

Note. Statements considered to describe a Fundamental Endovascular Skill (FES) by consensus are in bold.

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