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ORIGINAL ARTICLE

Development and delivery of a national pilot programme of home-based simulation for vascular anastomosis training

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Abstract

Background: Simulation for acquisition of technical skills in vascular surgery is an increasingly important educational resource, particularly in the COVID-19 era. However, there is a need to provide more equitable access to regular technical skills practice for UK trainees. **Methods:** A programme of home-based simulation for technical skill acquisition in vascular anastomosis was developed and delivered to all ST3 vascular trainees in the UK and Ireland over 4 months. Each trainee was provided with a kit box and access to dedicated online learning resources. Trainees were able to practice each task multiple times before uploading a video of their final performance to a file-sharing platform. Written feedback was then provided by a vascular consultant using a previously validated assessment matrix. **Results:** Twenty-four ST3 vascular trainees were enrolled in the VASIMULATION programme. Of these, 15 of 24 (63%) completed one or more tasks, although only one trainee completed all tasks. The median number of days for task completion was 19 days (range, 3–73 days). The post-programme survey was completed by 7 of 15 (47%) trainees who had completed at least one task. Both the models and kit boxes received positive feedback, and all trainees agreed that the range of tasks was appropriate for ST3 vascular trainees. The quality of feedback received was rated as excellent (43%), very good (43%) or good (14%) although 57% stated they had some difficulty uploading a video of their task performance for feedback. All respondents believed participation in the programme had improved their confidence in performing an end-to-side anastomosis, and 86% believed that it had improved their technical ability. **Conclusions:** VASIMULATION is the first national programme of home-based open vascular simulation training. It demonstrated that technical skills training can be delivered remotely, which could help to overcome geographic disparities in access to simulation. However, further work is needed to evaluate strategies to maximize trainee engagement.

Keywords: *simulation; training; open vascular surgery; vascular skills*

Introduction

The COVID-19 pandemic has served to underline the inherent vulnerability of the traditional apprenticeship model of surgical training.[1–3] In the UK, normal provision of surgical services has been significantly disrupted by the re-deployment of staff and beds for COVID relief efforts.[4–6] Consequently, 81% of trainees believed they missed out on acquiring core competencies, as highlighted in the GMC's 2020 National Training Survey.[7] Although trainees have undoubtedly gained other important skills and experience, limited operating means fewer training opportunities for development of technical skills. The impact of COVID-19 on routine surgical service provision (and the ability to safely deliver additional face-to-face teaching) provides a unique opportunity to re-evaluate current strategies for surgical training.

Simulation allows surgical trainees to acquire skills through deliberate, repeated practice in a structured environment.[8] Although it cannot replace learning in a clinical setting, simulation-based training can provide a planned schedule of learning events on which clinical experience can be built.[9,10] In addition, simulation can help to protect patients by ensuring that early learning happens in a safe, no risk setting.[11]

The UK Vascular Surgery Curriculum currently delivers annual simulation training to all trainees through national ASPIRE courses. These provide dedicated teaching for each trainee cohort from basic open and endovascular skills on ASPIRE3 to advanced operative skills on the ASPIRE6 cadaveric course.[12] However, access to regular local or regional simulation-based training remains variable, with many trainees having limited opportunities for repeated technical skills practice between courses.[13,14]

This article outlines the design, delivery and initial evaluation of the first national programme of regular home-based technical skills simulation (VASIMULATION) for junior vascular trainees. The programme was based on best-practice evidence for effective simulation and aimed to ensure equality of access for all trainees.

The primary aim was to develop and deliver a home-based programme of open technical skills simulation training for vascular trainees in their first year of specialty training (ST3). The secondary aims were to assess whether this simulation programme improved junior vascular trainee's confidence and ability in performing a vascular anastomosis using validated assessment metrics.

Methods

The aim of the VASIMULATION programme was to reconcile the principles of effective simulation with the practicality of delivering this to all trainees. Specific features supported by the published literature are outlined in Table 1.

Kit boxes

A low cost, portable kit box was developed, which contained all surgical instruments, sutures, vessel models (artery, vein and vein patch), gloves, pad for sharps disposal, syringe with needle (for water to lubricate vessel models as required) and a sponge jig (Fig. 1A and B). The sponge aimed to replicate some of the physical ergonomics of operating by mimicking subcutaneous tissue surrounding the vessels. Two small pins were used to keep the artery model in a pre-cut groove for the duration of the task and double-sided sticky tape temporarily anchored this jig to a suitable flat surface during practice sessions.

To keep costs low, competitively priced surgical instruments were sourced online, sutures were ordered in bulk through the NHS and additional components were purchased from local supermarkets and hardware shops. Some expenses (such as use of double-ended 5/0 Prolene sutures, Ethicon) were considered to be important to confer appropriate realism, but others that provided minimal educational benefit (such as the cost of specialist angled Potts scissors simply to extend the arteriotomy) could not be justified. The basic cost was approximately £24/box, with an additional £150 for models and sutures to complete all tasks.

Table 1. Features considered when designing a new programme of simulation for vascular trainees

Features of a simulation programme	Choice for VASIMULATION	Justification
Choice of tasks	Vascular anastomosis (arteriotomy and patch repair, end-to-side anastomosis and "parachute" technique)	Identified as a priority for simulation training[7,8] Significant improvement in confidence and technical skill after one or more simulation sessions demonstrated repeatedly[15–21] Range of task difficulties important for effective simulation[22]
Learner group	ST3 vascular trainees (UK and Ireland)	Junior trainees, in particular, benefit from vascular anastomosis simulation during early development of psychomotor skills[18,23] Vascular trainees with a National Training Number may be more likely to invest time in developing core skills relevant to their training curriculum[24]
Schedule of practice	3 practice attempts per task before assessment Each task undertaken over 2 weeks	Deliberate, repeated practice known to be important for acquisition of complex motor skills[25] Distributed practice appears to be more effective than massed teaching[10,15,19]
Location of practice	Home-based	Most simulation studies on skill acquisition for vascular anastomosis are in dedicated skills labs but this is costly and may limit access to regular practice[15,17,18,26] Take-home laparoscopic simulators have been shown to be effective[27–29]
Method of teaching	Online tutorial videos	Standardized teaching improves junior trainee skill acquisition compared with sessions with a variable format and structure[30,31] Instructional videos can promote skill acquisition, even in the absence of feedback32
Assessment and feedback	Modified Objective Structured Assessment of Technical Skills (OSATS) completed by expert faculty	OSATS previously validated for assessment of vascular anastomosis[16,33,34] Expert (rather than non-expert) feedback may allow trainees to achieve technical proficiency more quickly[35] Meta-analysis shows feedback given after (rather than during) completion of simulated task is more effective for skill retention in novice learners[36]

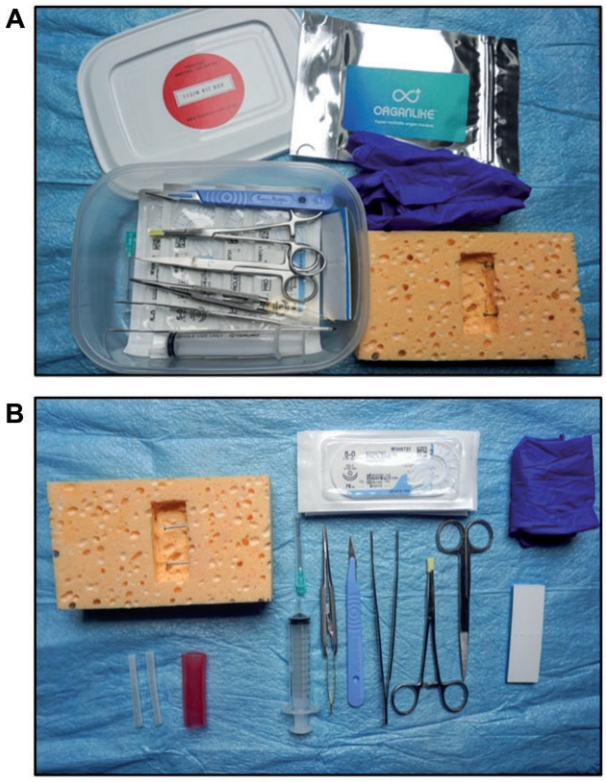

Figure 1. VASIMULATION kit box (A) and contents (B).

Online resources

Instructional videos for each task were filmed with a consultant vascular surgeon using the hydrogel models and kit box to demonstrate each task, with a particular focus on the important steps and common pitfalls (Supplementary Videos 1–3). A dedicated website (www.vasimulation.co.uk) was created to host the videos, as well as provide an interactive discussion board to address any issues, concerns or questions throughout the programme. Trainees were contacted individually by email at regular intervals with reminders to complete tasks. The project email address was checked daily to ensure prompt response to any queriers or troubleshooting issues that arose. Twitter (@vasimulation) and Instagram accounts (#vasimulation) were also used as alternative online platforms to connect with trainees and raise the profile of the VASIMULATION programme.

Task timetable

Trainees were asked to work through a series of tasks (Task 1, arteriotomy and patch closure; Task 2, end-to-side anastomosis; Task 3, anastomosis using the parachute technique) with the opportunity to practise each task multiple times before assessment. The models allowed trainees to practice each task up to three times before recording their performance of the fourth task for assessment, although the number of practice attempts made by each trainee before assessment was not recorded. Blinded evaluation of a pre- and post-programme end-to-side anastomosis was also intended to allow objective evidence of skill acquisition.

Overview of VASIMULATION programme delivery

The VASIMULATION programme was launched at the ST3 ASPIRE course in September 2019 and ran for 4 months. All attending ST3 vascular trainees from the UK and Ireland (n=24) were invited to enrol. Trainees who volunteered to take part were asked to complete a consent form and short questionnaire detailing basic demographics, previous experience and self-rate competence performing vascular anastomosis. At the end of the scheduled simulation skills workshop, trainees were videotaped performing an end-to-side anastomosis using the kit boxes and models to establish their baseline pre-test skill level.

Trainees were each given a kit box to take home, along with models and sutures for Task 1. To receive written feedback from a vascular consultant, trainees were asked to record and upload a video of themselves performing each task to a Dropbox account (Fig. 2). Fresh models, sutures and gloves were then sent out for the next task via first class post. Written feedback using a modified Objective Structured Assessment of Technical Skill (OSATS) matrix (Supplementary material) was completed and emailed to each trainee. Following completion of Task 3, trainees were asked to upload a final video demonstrating their best end-to-side anastomosis as a post-test.

All trainees were sent personalized emails at monthly intervals throughout the programme to encourage participation and report any difficulties.

Evaluation

At the conclusion of the VASIMULATION programme, all trainees were asked to complete an anonymous online survey to assess any changes in self-rated confidence, evaluate satisfaction with the programme and help identify areas for improvement. The surveys were created using the University of Aberdeen SNAP software to ensure compliance with General Data Protection Regulations, with an electronic hyperlink emailed directly to each trainee.

Results

Twenty-four trainees from all 15 deaneries in the UK and Ireland enrolled in the VASIMULATION programme; 58% were male and 42% were female. Previous experience in vascular surgery (since medical school) ranged from 0 months to 24 months, with a median of 12 months. Operative experience for vascular anastomosis was variable;

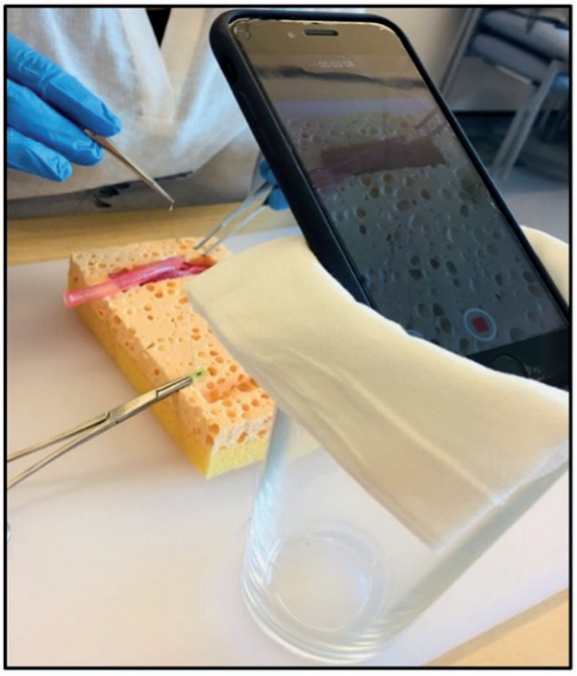

Figure 2. Suggested setup for self-videoing tasks.

8 trainees (33%) had never previously performed a complete end-to-side anastomosis and only 1 (4%) trainee had performed 11 or more. Trainee self-rated confidence in performing arteriotomy with patch repair and end-to-side anastomosis before the VASIMULATION programme is shown in Table 2.

Nine of 24 (38%) trainees did not submit videos for any tasks. A task video for arteriotomy and patch repair (Task 1) was uploaded by 15 of 24 trainees (63%). A task video for end-to-side anastomosis (Task 2) was uploaded by 10 of 24 trainees (42%) and a video for the parachute technique (Task 3) by 6 of 24 trainees (25%). Only one trainee submitted videos for all tasks and the post-test.

The median number of days for task completion was 19 days across all tasks (range, 3–73 days). The median length of a video was 20 min (range, 14–35 min). The median number of days from video upload to feedback was 6 days for Task 1, 8 days for Task 2 and 22 days for Task 3.

A summary of the mean OSATS scores for the procedural checklist and Global Rating Scale (GRS) are shown in Table 3. Given the small (and decreasing) sample size, formal testing of statistical significance was not performed. Although there is a small positive trend towards improvement in the total checklist and GRS scores, it is difficult to comment further given the number of participants, particularly for Task 4.

The post-programme survey was completed by 7 of 15 (47%) trainees who had completed at least one task. Despite emphasizing the importance of feedback from trainees who had not participated in the VASIMULATION programme, none of the remaining 12 trainees returned the post-programme survey.

Of those who responded, all believed that simulation was a valuable adjunct to operative experience during vascular training and 5 of 7 (71%) believed there should be greater emphasis on simulation within the vascular surgery curriculum.

Both the models and kit boxes received positive feedback; trainees rated the models as excellent (57%), very good (14%) or good (14%) compared with other models used previously for simulation of open technical vascular skills and 86% stated the equipment provided in the kit boxes was adequate to complete the tasks. All trainees agreed that the range of tasks was appropriate for ST3 vascular trainees, although 29% believed there were too many tasks and 14% believed there were not enough.

Most trainees practised a task twice before uploading a video for feedback; 86% of trainees rated the number of practice attempts for each task as about right. Unfortunately, 57% stated they had difficulty at some point uploading a video of their task performance for feedback. The quality of feedback received was rated as excellent (43%), very good (43%) or good (14%).

Overall, most of the trainee respondents were positive about the VASIMULATION programme. All trainee respondents believed participation in the programme had improved their confidence in performing end-to-side anastomosis, and 86% believed that it had improved their technical ability.

Discussion

The VASIMULATION programme represents the first national pilot of home-based simulation for vascular surgery trainees in the UK and Ireland, which aimed to facilitate deliberate, repeated practice using portable kit boxes, online learning resources and the provision of remote feedback on task performance videos. Although there was insufficient engagement to fully evaluate the impact of the programme on trainees' technical skill acquisition, the post-programme evaluation suggests that trainees who did participate found it beneficial.

Learner group

ST3 vascular trainees were selected to participate in the VASIMULATION programme because this cohort was

Table 2. Trainee self-rated confidence with anastomosis before VASIMULATION

Task	Pre-programme level of self-rated confidence (%)			
	Not at all	Confident to describe steps	Confident to perform parts under supervision	Confident to perform whole procedure
Arteriotomy and patch	0 trainees (0)	3 trainees (12)	10 trainees (42)	11 trainees (46)
End-to-side anastomosis	2 trainees (8)	6 trainees (25)	9 trainees (38)	7 trainees (29)

Table 3. Checklist and Global Rating Scale (GRS) scores for each task in the VASIMULATION programme

Task	Number of videos assessed	Mean total checklist score (range, 0–36)	Mean GRS score (range, 1–5)
1	15	27.3	3.28
2	10	28.4	3.54
3	6	31	3.64
4	2	28.5	4

unlikely to have considerable operative experience in vascular surgery and would therefore benefit most from simulation training on simple bench-top models. This assumption was corroborated by the pre-programme survey results, which showed that most trainees did not feel confident in performing a complete end-to-side anastomosis. However, the structure of vascular specialty training means that trainees undertake either 12 months of general surgery or 6 months of general surgery and 6 months of vascular surgery during their ST3 year. As a result, trainees in general surgery may not have had the same opportunities to consolidate learning with the transfer of skills into operative practice compared with those with a dedicated rotation in vascular surgery. Conversely, ST3 trainees may appreciate being able to maintain or improve vascular-specific technical skills during their general surgery placements, particularly if they feel disengaged from their parent specialty. Further qualitative research would therefore be useful to elicit trainee's views on the timing of vascular-specific simulation during the early years of specialty training.

Trainee engagement

Overall, more than half of the ST3 trainees (54%) participated in the VASIMULATION programme, although only one trainee (4%) completed all tasks. In many ways, this is comparable with other early experiences after the introduction of new programmes of home-based simulation. For example, during the first year of the Incentivised Laparoscopic Practice Study (ILPs) 12 of 27 trainees (44%) completed $\geqslant 1$ task and only seven trainees (26%) completed all tasks.[15] Although both ILPs and the VASIMULATION programme were specifically designed to address concerns that lack of access to simulation facilities out-of-hours prevented opportunities for self-directed learning, it is clear that the provision of simulation equipment alone is insufficient to ensure adequate participation.[13]

Blackhall et al.'s[16] qualitative follow-up study on ILPs highlighted several other common barriers to engagement with laparoscopic simulators, including lack of applicability to future specialty, dissatisfaction with metric feedback and perpetuation of a tick box culture. The VASIMULATION programme aimed to address these issues by providing simulation of index vascular procedures for early years vascular specialty trainees with the provision of descriptive, individualized feedback and numerous online platforms to promote participation.

However, it is clear that other factors continue to have an impact on trainee engagement. Although the post-programme survey did not demonstrate significant dissatisfaction with the VASIMULATION models and kit boxes provided, it did reveal that some trainees experienced technical difficulties (e.g. with video uploads). Throughout the programme, trainees were contacted regularly by email and encouraged to ask for help if required. In one case, this allowed an alternative upload strategy (dividing into two shorter videos) to be used successfully. Unfortunately, most trainees did not highlight these difficulties until after the VASIMULATION programme had closed.

In addition, the low response rate limits the wider applicability of these results. It would have been particularly valuable to have feedback from those trainees who did not complete any tasks to elicit whether these or other unidentified factors had the greatest impact on willingness or ability to participate. It would also be useful to ascertain whether the influence of a tick box culture, in which trainees believe they must continually prioritize other activities (such as audit or research) rather than spend time developing good surgical skills, persists even after trainees secure a

National Training Number. Therefore, further research is needed to investigate the range of factors that may influence participation in self-directed simulation training among vascular trainees.

Choice of tasks

All respondents to the post-programme survey believed the tasks were appropriate for an ST3 trainee. However, the number completing each task declined progressively over the duration of the programme, although the reasons for this are unclear. However, as there are no published studies outlining the optimal series of simulated tasks to provide a foundation for open anastomotic technical skills, a degree of trial and error is required to test possible task combinations. In addition, part of the rationale for the programme, according to Ericsson's theory of expertise,[17] was to provide maximal opportunity for deliberate, repeated practice of relevant anastomotic skills. Further research would be beneficial to establish whether trainees understand and apply such educational principles when engaging with simulation.

Schedule of practice

The VASIMULATION programme launched at the ASPIRE3 course in September 2019 provided the only opportunity to have all ST3 trainees together. However, this also coincided with the beginning of specialty training and thus may have been a particularly challenging time (both personally and professionally) for many trainees.

Although a distributed schedule of practice has been shown to be beneficial for technical skill acquisition, there is little consensus on the optimal duration, number or frequency of training sessions,[18,19] Bismuth et al.[20] acknowledge that this lack of research on learning curves specific to vascular procedures makes it particularly difficult to determine the time required for simulation within existing training curricula. In addition, it was impossible to anticipate the impact of different work schedules and other commitments on each trainee's ability to complete tasks from month to month.

The schedule for the VASIMULATION programme was therefore pragmatic, rather than strictly evidence based. To maximize participation, trainees were able to work through the tasks at their own pace, although a recommended timetable was provided as a guide. However, it is unclear whether this flexibility also contributed to a lack of motivation for trainees to complete all tasks within the given time period. To gain further insight, it would be necessary to gather information about the impact of the timing and duration of the VASIMULATION programme on trainees' ability to participate, as well as whether definite cut-off dates for feedback would have promoted task completion.

Recruitment of faculty

The limited availability of simulation faculty has been highlighted repeatedly as a barrier to the provision of simulation-based training in surgery.[11,13,14,20] Although the VASIMULATION programme prompted considerable interest and enthusiasm from a range of vascular consultants, it proved difficult to recruit faculty who could find time aside from existing clinical and teaching commitments. In addition, trainers often feel that teaching commitments are given less priority than other activities by both senior managerial staff and in appraisals.[21,22] Ongoing reliance on the goodwill and enthusiasm of a select few individuals for simulation training is unsatisfactory and unsustainable.[14] Clearly, strategies to address this must be a priority if simulation-based training is to be more widely incorporated into surgical curricula in the future.

Feedback

Feedback is recognized as critical to the success of simulation-based training.[23] Overall, trainees were positive about the quality of feedback received, although it is acknowledged that the lag between task completion and receipt of feedback was often longer than would have been desirable. Although having a single reviewer for all videos provided a degree of consistency in marking, this also meant it was not possible provide feedback within a few days of video upload, particularly given the average duration of a video was 20 min. Ideally, any future VASIMULATION programme would have several clinicians to review and provide feedback on the task videos. This would also allow assessment of inter-observer reliability to test the validity of the assessment matrix used for feedback. One alternative may be to consider scheduling online sessions for live feedback rather than asking trainees to upload video files. However, further trainee input would be valuable to help reach consensus on the style, content and timing of feedback that optimizes learning during home-based simulation.

Limitations

The specific features of the VASIMULATION programme (tasks, learner group, practice schedule, remote access, etc.) were purposefully selected based on best available evidence, but it is clear there were other, unanticipated barriers to trainee participation. Further research is needed to fully elicit these barriers to improve engagement with home-based simulation in the future, particularly as the post-programme survey was completed by only 30% of all trainees who enrolled in the VASIMULATION programme. Furthermore, it would be valuable to assess whether the results are more widely generalizable beyond this trainee cohort.

Conclusion

This study aimed to evaluate whether delivering a national programme of home-based practice for vascular skill acquisition is achievable and, importantly, of benefit to trainees. Although the VASIMULATION programme improved trainees' self-rated confidence and technical skill in performing vascular anastomoses, overall trainee engagement was suboptimal. Despite a wealth of educational theory supporting the design of the VASIMULATION programme, there is a clear need to better understand how regular simulation-based training can be most effectively delivered within the current vascular curriculum. This is particularly pertinent in the COVID-19 era, providing additional opportunities for technical skill development out with the clinical environment.

Supplementary material

Supplementary Video 1. Arteriotomy and patch closure. Available online at: https://youtu.be/1czgojIcUNc

Supplementary Video 2. End-to-side anastomosis. Available online at: https://youtu.be/9uT9OjdE65U.

Supplementary Video 3. Parachute technique. Available online at: https://youtu.be/IXR_PpLMVBQ.

Modified Objective Structured Assessment of Technical Skills (OSATs) matrix. Available online at: https://doi.org/10.5281/zenodo.6832368.

Conflict of interest

None declared.

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