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Elena Iborra *, Malka Huici-Sanchez , Otilia Chaos , Irene Macía , Sebastián Videla

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Article

Teamwork in Action: Improving Emergency Response for Ruptured Abdominal Aortic Aneurysms Through Simulation Training

Elena Iborra [1,2,3,*], Malka Huici [1], Otilia Chaos [1], Irene Macía [4] and Sebastià Videla-Cés [5,6]

[1] Vascular Surgery Department, Bellvitge University Hospital, L'Hospitalet de Llobregat, 08907 Barcelona, Spain
[2] IDIBELL-BIOHEART, Bio Heart Cardiovascular Diseases Research Group, Bellvitge Biomedical Research Institute (IDIBELL), L'Hospitalet de Llobregat, 08907 Barcelona, Spain
[3] Department of Clinical Sciences, School of Medicine, University of Barcelona, 08907 Barcelona, Spain
[4] Anaesthesiology Department, Bellvitge University Hospital, L'Hospitalet de Llobregat, 08907 Barcelona, Spain
[5] Clinical Research Support Unit, Clinical Pharmacology Department, Bellvitge University Hospital, L'Hospitalet de Llobregat, 08907 Barcelona, Spain
[6] Clinical Research Support Unit, Clinical Pharmacology Department, Germans Trias i Pujol University Hospital, 08916 Badalona, Spain
* Correspondence: eiborra@bellvitgehospital.cat

Abstract: Background: Ruptured abdominal aortic aneurysms (rAAA) have a high mortality rate, close to 50%, despite a decrease in incidence in many European and American countries. Improving emergency response through simulation training could significantly enhance patient outcomes. **Objective**: To determine whether simulation training and theoretical sessions reviewing the clinical practice protocol for rAAA management improve emergency team performance. **Methods**: Prospective, single-center, evaluative study on teaching activities based on a course for managing ruptured abdominal aortic aneurysms (rAAA) through teamwork simulations conducted at Bellvitge University Hospital, a tertiary care center. The study included vascular surgeons, anesthesiologists, scrub nurses, and porters. The intervention consisted of a course on rAAA management, including protocol revision and simulation sessions. **Results**: A total of 35 participants (mean age 35.1 (27-55), 40% male) completed the course. The time between the emergency call and patient treatment was significantly reduced from 41 minutes to 31 minutes (a 24,5% reduction time). All participants reported high satisfaction with the course and perceived significant improvement in their skills. **Conclusions**: Simulation training and theoretical sessions on rAAA management significantly improve emergency team performance and shorten the time between the emergency call and patient treatment. This study provides a replicable methodology that can be implemented in other medical centers to enhance emergency response.

Keywords: team-training; ruptured abdominal aortic aneurysm; simulation

1. Introduction

Despite an ageing population, ruptured abdominal aortic aneurysms (rAAA) have decreased in many European and American countries [1]. Unfortunately, mortality remains above what would be optimal, with data near 50% [1–3]. These data could be improved by implementing a multilevel approach that considers institutional, staffing, preparation, supply stock, educational, and financial factors [4,5].

Several centres in our area treat less than twenty patients with rAAA annually but must be prepared for a quick and adequate response [2,3]. Teamwork simulations could be a good training opportunity: practicing in a real scenario without the pressure of a vital emergency [6–9]. However, simulation is not used regularly, probably due to a lack of time, simulation experts, personnel dedicated to the sessions, or logistical organisation.

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We developed the Ruptured Abdominal Aortic Aneurysm clinical practice protocol (https://bit.ly/3nJPO02) to manage rAAA in our area of influence. Vascular surgeons (VS) promoted it and collaborated with anesthesiologists (ANR), scrub nurses (SN), porters (P), radiologists, general surgeons, the emergency department staff, and the medical emergency service in charge of patient transfer. The protocol included instructions on the patient's clinical management, logistics during the process and the distribution of tasks according to the professional role.

We hypothesised that training simulation and theoretical sessions reviewing the clinical practice protocol of rAAA management could enhance our team's performance. Therefore, we designed a course that included protocol revision and simulation sessions to improve our emergency teams' abilities and shorten the time between the emergency call and the patient's treatment. Herein, we share our experience.

2. Materials and Methods

2.1. Study Design

We present a prospective, unicenter, evaluative research on teaching activities based on the cohort of participants from a tertiary hospital who attended a rAAA management course. The study was approved by the centre's Institutional Review Board (Ref. PR314/22). Written informed consent was obtained from all participants. Likewise, participants consented to use the recordings' images by anonymously filling out and delivering the questionnaires. The study followed the updated Declaration of Helsinki, Good Clinical Practice guidelines, and the applicable Spanish regulatory requirements. Confidentiality was guaranteed according to the current Spanish legislation (LOPD 3/2018). This manuscript complies with STROBE guidelines [10].

2.2. Study Population

We invited all members of the aortic emergency staff from our tertiary hospital (Bellvitge University Hospital) to participate in this course on rAAA management: vascular surgeons (fellows and trainees), anaesthesiologists (fellows and trainees), scrub nurses, and porters. Participation was voluntary. Hence, this study included members of the aortic emergency staff (adults≥18 years of both sexes) who agreed to participate.

Before the beginning of the course, we informed possible participants about the study's background, objectives, and methods, as well as the review board's permission and their ability to reject or discontinue participation at any moment without facing any repercussions.

The following anonymised data were entered into an ad hoc-created electronic case report form (eCRF): date of birth, participant's biological sex (male/female), date of course sessions, time spent in different stages (minutes) of the various sessions and whole course time based on video gathered during the sessions.

2.3. Course of Ruptured Abdominal Aortic Aneurysms Management

We designed a course to test team performance on rAAA management, aiming to increase the emergency teams' skills and reduce process time. The tertiary hospital training department and the Institut Català de la Salut recognised the course as a multidisciplinary activity.

Initially, a steering team was created, which involved at least one member of each professional group who prepared and led the simulations and theoretical sessions and analysed their peers' development during simulations.

One week before starting the course, we emailed all the protocol information to the participants.

The course consisted of three different sequential teaching activities:

1. A simulation session in a natural environment [hybrid-Operating theater, (hybrid OT) Azurion, Philips®] was performed. The different professionals, VS, ANR, SN, and P, had to reproduce the management of a newly diagnosed patient in the same facility. It was meant to last 150 minutes.

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2. After all emergency teams finished the first simulation session, a theoretical session was performed for each professional group. This included an academic review of our clinical practice protocol of rAAA management, especially dealing with the areas of interest of every group. In addition, the simulation videos were reviewed to analyse everybody's performance. It was meant to last 120 minutes.
3. A second simulation session, which was meant to last 150 minutes, was conducted to apply the improvements detected in the previous sessions.

2.3.1. Procedure of the Simulation Sessions

The goal of the simulation session was to mimic the actual management of an rAAA from the emergency call until the patient's stabilisation with an intra-aortic balloon. The two simulation sessions worked similarly.

- *Emergency teams:* The steering team randomly created 'emergency teams' among participants. The emergency teams comprised at least two VSs, two ANRs, four SNs, and one P. Each professional group wore a different surgical hat to facilitate identification during video analysis and for participants to easily recognize each other: VS red, ANR yellow, SN green and C blue.
- *Location***:** The sessions started with the patient (a dummy) at the emergency computed Tomography (CT) scan area on the hospital's main floor. The rest of the session occurred at the surgical site on the hybrid OT (third floor).
- *Stages*: We differentiate four sequences: first, a briefing explaining the exercise and defining the different roles; second, the simulation exercise; third, the collection of the surgical area leaving the hybrid-OT ready to use; and fourth, a debriefing to share the experience with the team, conducted by the simulation instructors. We used Sharp®, Talk®, and TeamSTEPPS® tools to debrief more appropriately [8,9].
- *Expected Timing*: Briefing 30 minutes, simulation 45 minutes, collection 15 minutes, debriefing 60 minutes: Total Simulation time150 minutes.
- *Simulation instructor:* One instructor for every professional category would take notes and record the activities on a checklist. This information would help during the debriefing stage.
- *Materials:* The exercise used a plastic aorta model mounted on a dummy. Puncture and working with the guides, sheaths, and catheters were possible. It was a simple model without tortuosity or dilations to provide equal conditions for all teams.
- *Script:* The trainee vascular surgeon receives the call of a newly diagnosed rAAA at the CT scan area and starts the process. He communicates with the on-call vascular surgeon, the anesthesiologist and the nurses to prepare the hybrid OT. The nurses and anesthesiologists will prepare all the medication and equipment, waiting for the patient's arrival. The trainee vascular surgeon and the anesthesiologist will check on the patient, decide on surgical treatment, and activate the transfer to the OR. In the meantime, the on-call vascular surgeon will check on the CT images to decide surgical strategy and communicate it to the rest of the team. Once the patient arrives at the hybrid OR, every participant performs the different steps to complete the treatment. The exercise finishes when the patient is stable with an intra-aortic balloon.
- *Surgery:* The surgical team should follow all the steps to insert an intra-aortic balloon: eco-guided arterial puncture with micropuncture set, hydrophilic wire, 5F sheath, multipurpose catheter, Lunderquist wire, 16F sheath, and the compliant balloon inflated above the visceral vessels.
- *Times recorded:* We recorded the time spent in different simulation stages: briefing, simulation, collection, and debriefing. We also analysed the time spent during the simulation stages between the emergency call and the theoretical patient's stabilisation with an intra-aortic balloon: treatment time.

The rAAA management included role cards summarising all the actions they must perform at each simulation stage. The participants were able to use them during the exercise.

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We had images from three cameras: two in the operating theatre and one in the corridor. We recorded all simulation sessions to check on time spent at every stage, team organisation, noise in the hybrid-OT, and participant movements. We then qualitatively assessed the video recordings.

2.3.2. Procedure of the Theoretical Session

There were four theoretical sessions: VS, ANR, SN, and P. The steering team members of every group prepared the sessions, which were meant to last 120 minutes and included an academic review of the protocol and the teams' performance during the simulations.

2.4. Assessment of the Performance Improvement and Satisfaction

We assessed performance improvement and satisfaction using a six-question survey completed by all participants before and after the simulations using a five-point Likert Scale (one: strongly disagree, five: strongly agree) (6). The questions were:

- I feel confident in my abilities
- I know my role during surgery
- I manage well during surgery setting
- I am aware of the role of my colleagues
- I have enough experience to carry out the treatment of an AAAR
- I consider the simulation useful for my training

We also conducted a final course evaluation survey to know participants' opinions on the course characteristics. The questions were:

- Do you consider that the theoretical session has strengthened your knowledge?
- Do you consider that the theoretical session has strengthened the standardisation of teamwork?
- Could you implement the knowledge acquired within your role during the second simulation?
- During the second simulation, are you more aware of the role of your colleagues?
- Do you think communication within your team has improved?
- Do you think that the organisation within your team has improved?
- Do you think the course format with the first, theory, and second simulations has been valid?
- Do you think adding training in any aspect would be necessary?

2.5. Impact on Our Clinical Practice Protocol of rAAA Management

Once the course was completed and analysed, the steering team evaluated and proposed changes to our clinical practice protocol of rAAA management to improve it.

2.6. Statistical Analysis

Given the study's descriptive nature, no formal sample size was calculated. The final sample size included the rAAA-Course participants who agreed to participate.

A standard descriptive analysis of the demographic data was performed. Categorical variables were expressed as absolute and relative frequencies. Quantitative variables were expressed as median (range: minimum-maximum) or mean (standard deviation [SD]).

An exploratory analysis between simulation sections was done. Statistical significance was set at a p-value of less than 0.05. All statistical analyses were performed using SPSS software for Windows (version 25.0; SPSS Inc, Chicago, IL, USA).

3. Results

3.1. Baseline Characteristics

The course took place over five months. A total of 36 participants from the aortic emergency staff were invited to participate (9 VS, 8 ANR, 14 N and 5 P). Thirty-five accepted participation and signed

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the written informed consent (9 VS, 7 ANR, 14 N and 5 P). All completed the course. Table 1 shows the baseline characteristics. A total of 3 emergency teams were created. Every group had three VS, two or three ANR, four or five SN and one or two P.

Table 1. Baseline characteristics are divided into professional roles.

		All n=35	Vascular Surgeons n=9	Anesthesiologists n=7	Nurses n=14	Porters n=5
Age (years)	**median (range)**	35.1 (27-55)	40 (27 – 53)	32 (28 – 44)	33.5 (28 – 55)	35 (30 – 40)
Male / Female	**n (%) / n (%)**	14 (40%)/ 21 (60%)	4 (44.4%) /5 (55,6%)	2 (28.6%) /5 (71.4%)	4 (28.6%) /10 (71.4%)	4 (80%) / 1 (20%)

3.2. Outcomes of Ruptured Abdominal Aortic Aneurysms Course

Every emergency team performed two simulations according to the course schedule. Therefore, we conducted six simulations and four academic sessions, one for each professional category: VS, ANR, SN, and P. We ran the first simulation sessions on three consecutive Tuesday afternoons. One month later, we conducted the theoretical sessions. The second simulation sessions were held on three successive Tuesday afternoons two months after the academic sessions (three months after the first simulation session).

Table 2 summarises the timings during the first and second simulation sessions. The second simulation lasted less time than the first one in two groups. In group 1, the increase was due to more extended briefing, collection and debriefing times. All groups decreased treatment time with a time reduction between simulations (difference between first and second simulation) of 12 (27.3%), 8 (20%) and 10 (26.3%) minutes in each emergency team, respectively. If all emergency teams were considered one, treatment time improvement would be 10 (24.5%) minutes. This improvement was related to faster transfer to the operating theatre and earlier start of surgery (from 35.33 to 26.33 minutes). The time from puncture to balloon placement was similar (from 7 to 5 minutes).

Table 2. Timings during the first and second simulation sessions.

Emergency team	Briefing		Simulations		Collect		Debriefing		Whole time	
Simulation	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
#1	40	55	44	32	26	30	75	88	185	205
#2	53	53	40	32	27	34	75	70	195	189
#3	53	49	38	28	29	29	80	78	200	184

* Data in minutes.

3.3. Logistical Issues During the Course

Some logistical difficulties arose during the rAAA course but did not prevent its completion. Due to a real emergency procedure, the hybrid OT was unavailable for one of the first simulation sessions. We performed the simulation in a regular operating room with a mobile C-arm.

3.4. Performance Analysis

Supervision during simulations and video recordings were used to analyse team performance. Several organisational issues during the first simulations were corrected during the second ones: repeated equipment movements, useless actions, or lack of material preparation. Team organisation improved: everyone followed their role more accurately, avoiding unnecessary movements. Communication was also more effective, resulting in calmer and quieter simulations.

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3.5. Improvement and Satisfaction

Thirty-four participants (97.1%) answered the first questionnaire, thirty (85.7%), the second and twenty-nine (82.9%) the final survey about the course.

Table 3 shows the participants' improvement and satisfaction with the evaluations before and after the rAAA management course. At the end of the period, all participants gained self-management and role knowledge (their own and others).

Table 3. Evaluation of improvement and satisfaction before and after the course of ruptured abdominal aortic aneurysm management.

		Pre-course n=34	Post-course n=30
I feel confident in my abilities	% of score ≥4 (n)	70.6% (24)	73.3% (22)
I know my role during surgery	% of score ≥4 (n)	70.6% (24)	96.7% (29)
I manage well during surgery setting	% of score ≥4 (n)	50% (17)	73.3% (22)
I am aware of the role of my colleagues	% of score ≥4 (n)	61.8% (21)	80% (24)
I have enough experience to carry out a rAAA treatment	% of score ≥4 (n)	29.4% (10)	46.7% (14)
I consider the simulation useful for my training	% of score ≥4 (n)	100% (34)	100% (30)

Regarding course evaluation, all participants agreed that the simulation provided good training and that the course design was ideal for achieving its goals. In the final assessment evaluation survey of the course, all responses were ≥4.

3.6. Impact on Our Clinical Practice Protocol of rAAA Management

After evaluating the experience and based on the results, the steering team changed role cards, creating a more equitable workload distribution between roles.

3.7. Budgets and Special Equipment

We performed the sessions using a dummy from the University of Barcelona. The aortic model was built using extracorporeal pump tubing and Penrose drainages. The materials we needed to set up the surgical area were reused throughout several sessions. No particular budget was provided

4. Discussion

This paper shares our successful experience performing simulation training of rAAA management in a real scenario. In this training, we experienced a 25% decrease in time from diagnosis to patient treatment and a better understanding and performance of the personnel and others' roles.

The purpose was to test the new rAAA management protocol and identify improvements in our centre's rAAA process, from the completion of the angio CT to surgical treatment, not only the surgical performance. Therefore, we designed a three-stage multidisciplinary course, simulation-theory-simulation, to test the team before and after theoretical training and check the protocol tools. Many experiences prove that fully immersive simulation in a controlled environment promotes the transfer of technical and nontechnical abilities to real-world circumstances without endangering the patients [11]. They are helpful for team training, detecting any errors that may occur in real life, and acting upon them may be adequate to prevent their appearance in the future [12]. Several works focus on surgeon simulation training needs [11,13–16]. Still, only some consider our multidisciplinary approach: working on technical and nontechnical skills for all team members and recognising non-medical professional profiles such as nurses and porters. All team members are essential for the process to develop optimally. During the sessions, we highlighted the importance of teamwork in carrying out the process: effective collaboration in the operating room is essential for safe surgical practice. Some studies emphasise that team skill deficiencies are frequently associated with adverse

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events and near-misses to surgical patients. In contrast, superior nontechnical skills and teamwork are associated with fewer surgical, technical, and procedural errors [14]. More broadly, multidisciplinary simulation of the theatre environment can aid in preparing teams for infrequently encountered scenarios such as surgical emergencies like rAAA [7], especially considering hospitals with surgeons in training, teams in continuous renewal and dealing with low-frequency pathologies [11] as we see in our environment.

When dealing with an emergency, knowing everyone's tasks is necessary to work efficiently without wasting time. We clearly defined everyone's actions and worked with the team before and after the simulation sessions, adapting the role cards used by Aho et al. [6]. During our simulation exercises, everyone had a card detailing all the tasks they had to perform at every stage. This tool, available to check during an emergency, can help professionals complete all the tasks correctly. As we can see from the questionnaire results, the course made everyone aware of their and others' roles, a clear improvement in our daily practice.

A checklist based on the role cards was used to check every team member's performance. An OTAS tool could have also been helpful, as it measures five observable teamwork behaviours: communication, coordination, cooperation, leadership and monitoring or situational awareness [13,14,17]. Another possibility would be using the Endo-OTAS, a tool explicitly designed to capture the quality of endovascular surgical teamwork [18]. We considered its use too complex for our experience as we were novice assessors with no expertise in OTAS. In the future, if we repeat the experience, we will adapt the endo-OTAS to our environment and assess the actions differently.

Time analysis shows an improvement in response time comparing first and second simulations. The team worked more neatly and efficiently in the second session compared to the first. When we analysed the videos, we observed less noise, more efficient movements, communication, and non-repeated actions. We have seen some progress in real-world teamwork: more effective with better relationships. To determine if there is an improvement in real-world response time, we are collecting the timing data of all rAAA patients in a prospective manner.

We assumed the simulation exercise would last 150 minutes when we designed the course. In practice, it was a mean of 193 minutes: We spent more time in all the stages. For future editions, we should schedule the exercise for 180 minutes and perform a more effective briefing and debriefing.

Considering debriefing, we used several tools adapted to our language: Sharp®, Talk® and TeamSTEPPS® [7,8]. During this stage, the teams had time to stop and discuss the experience and analyse their performance. Everyone could share their feelings and experiences, detailing actions to repeat the same and others to be corrected. The debriefing is an interactive process of bidirectional reflective analysis: feedback, positive comments, problems, errors or mistakes [16]. We realised we were beginners in the debriefing process. After this simulation training, we will probably use other tools and lead the debriefing differently based on a Plus Delta approach [19].

There are several limitations of this study. First, there was a lack of formal simulation training before the course. At that time, in our centre, there was no experience in surgical simulation with the characteristics we were planning. Better knowledge of simulation training would have allowed us to get even more out of the course, perform better data recording and analysis and improve the debriefing process. Second, we are now aware that participants should master the knowledge skills before attending the training session to optimise the use and efficiency of training time [12]. The investment in time and resources required for a simulation experience deserves prior preparation of the theoretical content.

After the course, we have seen an improvement in the operating room's working environment and everyday working conditions. Emergency vascular simulation is an innovative multidisciplinary training project that objectively measures the team's progress and helps improve response times. We should integrate this exercise into our daily workouts to maintain the team's performance, but we understand it could be very demanding regarding time and resources. Nowadays, we are developing a gamification project to train the team as a possible ally to our simulation program.

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5. Conclusions

The specific training course on ruptured abdominal aortic aneurysm management, based on simulation and review of clinical practice protocol, improved the skills of the emergency teams by reducing the response time during this vital emergency. Likewise, teamwork was enhanced with a high team satisfaction rate. Moreover, this training course has helped us improve our clinical practice protocol for rAAA management.

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Institutional Review Board Statement: The study was approved by the centre's Institutional Review Board (Ref. PR314/22). Written informed consent was obtained from all participants. Likewise, participants consented to use the recordings' images by anonymously filling out and delivering the questionnaires. The study followed the updated Declaration of Helsinki, Good Clinical Practice guidelines, and the applicable Spanish regulatory requirements. Confidentiality was guaranteed according to the current Spanish legislation (LOPD 3/2018). This manuscript complies with STROBE guidelines [10].

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data supporting reported results can be found and are available on demand.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

rAAA	Ruptured Abdominal aortic aneurysm
VS	Vascular Surgery
ANR	Anaesthesiology
SN	Surgical Nurses
P	Porter
Hybrid-OT	Hybrid Operating theater

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