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RESEARCH ARTICLE

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Team composition and staff roles in a hybrid operating room: A prospective study using video observations

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Abstract

Aim: The aim of the study was to evaluate team composition and staff roles in a hybrid operating room during endovascular aortic repairs.

Design: Quantitative descriptive design.

Methods: Nine endovascular aortic repairs procedures were video-recorded between December 2014 and September 2015. The data analysis involved examining the work process, number of people in the room and categories of staff and their involvement in the procedure.

Results: The procedures were divided into four phases. The hybrid operating room was most crowded in phase 3 when the skin wound was open. Some staff categories were in the room for the entire procedure even if they were not actively involved. The largest number of people simultaneously in the room was 14.

KEYWORDS

endovascular aortic repairs, hybrid operating room, nursing staff, staff presence, staff roles, team composition, video observations

1 | INTRODUCTION

Operating rooms (OR) represent a complex environment that includes highly advanced technology and a need of various specialist competencies. To ensure patient safety, staff in an OR must both have specific individual skills and work as a cohesive team (Cassera, Zheng, Martinec, Dunst, & Swanstrom, 2009). Working as a team in the OR has proven to be challenging and deficiencies in patient safety, procedure efficiency and well-being of the staff caused by communication failures are highlighted in the literature (Lingard et al., 2004). A hybrid OR can be described as an OR integrated with advanced radiological imaging equipment under strictly controlled aseptic conditions. Staff requirements in a hybrid OR during endovascular aortic repair (EVAR) go beyond ordinary OR staffing and usually include radiology staff, including radiologists and radiographers, due to the use of radiological equipment and the image-guided aspect of the procedure. Despite the growing number of hybrid ORs worldwide, the optimal composition and function of an OR team where radiology staff is included are an unevaluated research area and are the aim of this study.

1.1 | Literature review

Being able to perform both open surgery and percutaneous image-guided interventions in the same room, with no need to move the patient between different rooms for each procedure, is the main advantage with a hybrid OR (Nollert et al., 2012). A hybrid OR, thus, allows for easy and immediate conversion from an EVAR to open surgery in the same setting, if medically necessary. This improves patient safety and this flexibility can also result in shortened hospital

stays by avoidance of two separate hospital admissions if the patient would be scheduled for two different treatments (endovascular and open surgery). Consequently, one could expect higher patient satisfaction (Field, Sammut, Kuduvalli, Oo, & Rashid, 2009); however, this has not yet been confirmed in any study. Hybrid ORs are expected to have further advantages such as efficient workflow and economic gains if they are used by multiple surgical specialties and procedures (Kaneko & Davidson, 2014; Nollert et al., 2012). The limitations associated with a hybrid OR are scarcely described, but when they are, they tend to focus on aspects such as room space requirements and increased costs during construction. The research focus within the context of hybrid ORs continues to be of medical and technical nature (Ahmad, Obeidi, Majd, & Brunkwall, 2018; Andres et al., 2017; Fidalgo Domingos et al., 2018; McAnelly, Kelleher, Ibrahim, & Antoniou, 2017; Tsuei et al., 2018; Ujiie, Effat, & Yasufuku, 2017). However, the team approach is mentioned as the most critical factor in the success for a hybrid OR (Kaneko & Davidson, 2014), but to our knowledge, no studies focusing on the team composition or on the staff roles have been conducted.

1.2 | Problem identification

Endovascular aortic repairs (EVAR) within a Swedish context may require competence from anaesthesiology, surgery and radiology which theoretically means more staff involved, especially for the nursing staff. Nursing staff were defined as registered nurses, RNs, in this study. To maintain aseptic conditions, an OR should have a limited number of people to decrease microbes in the air, thereby reducing the risk of infection (Birgand, Saliou, & Lucet, 2015). Limiting the number of staff is also of interest when considering specialist staff shortages, production pressure and team functionality (Cassera et al., 2009). Simultaneously, the staff involved in an EVAR procedure must be skilled in different areas to achieve technical success and patient safety. The combination of specialties in the hybrid OR means that staff with different expertise, knowledge, professional cultures and thereby varying responsibilities and priorities have to collaborate and work as a cohesive team. This is particularly crucial for the RNs who represent anaesthesiology, surgery and radiology due to their common responsibilities in patient care but different professional cultural backgrounds.

This study focuses on team composition, staff roles and participation in the care and treatment activities during EVARs in a hybrid OR. As a step towards optimal team composition in a hybrid OR, it is essential to investigate the actual team composition and staff roles during EVARs to understand both how procedures can function effectively and how staff competencies can be used and further developed.

2 | AIMS

The aim of the study was to evaluate team composition and staff roles in a hybrid OR during EVARs by investigating: (a) How many people were present in the room during different phases of the procedure? (b) Which staff categories were present in the room during different phases of the procedure? and (b) To what extent were RNs (i.e., nurse anaesthetist, OR nurses, radiographers) involved in the procedures?

3 | METHODS

3.1 | Design

This study used a quantitative descriptive design based on observations from video recordings.

3.2 | Setting

The setting for the present study was a hybrid OR built as a prototype, commissioned in May 2011. The room was about 93 m^2. Radiological interventional equipment with robotic technology (Siemens Artis Zeego) and additional 105 medical devices were installed in the room. A total of 25 monitoring screens in different sizes with several purposes (patient monitoring, X-ray image guiding, documentation, image processing) were placed in different parts of the room. Two walls of the room were covered with storage cabinets. Already during the planning stage, the room was divided into three disciplinary sections (see markings in Figure 1) according to where different equipment would be placed. In the centre of the room, a combined operating-interventional patient table was situated, and the patient was generally positioned with his/her feet towards the entrance of the room. Above the patient head was the area for the anaesthesia equipment including three anaesthesia booms marked A, B and C mounted to the ceiling. There were also several mobile radiation protective walls in the room.

3.3 | Participants

Participants in this study were all staff that were in some way involved in the EVAR procedure. These included the physicians with specialization in either vascular surgery (vascular surgeon) or radiology

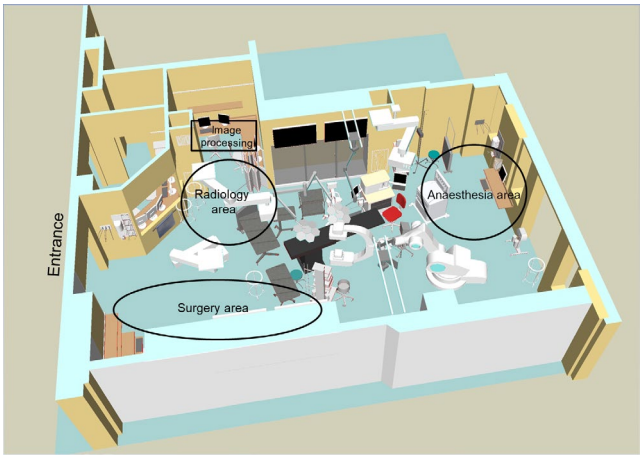

FIGURE 1 Three-dimensional illustration of the hybrid OR including equipment and devices. Source: Tyréns Arkitekter (used and modified with permission from Tyréns Arkitekter)

intervention (interventional radiologist) and the RNs which were the following staff categories: OR nurse, nurse anaesthetist and radiographer. The OR nurse and nurse anaesthetist both are registered nurses and have postgraduate diplomas in specialist nursing. In Sweden, the registered radiographer has a unique position with responsibility for the technical imaging aspects, medication and injections and other nursing aspects of care. A further staff category usually involved in the practical work in an OR is the OR assistant nurse who has secondary education and practical training in the OR room environment. The people that were present in the room but not involved in the EVAR procedure were named others.

3.4 | The cameras

Cameras used for audio/video recording in this study were installed for educational purposes when the room was initially built. There were two video cameras (Sony BRC-z700, HD 3 CMOS) mounted to the ceiling showing the whole room except for a small area called "image processing" (see Figure 1). One camera recorded the inner part of the room while the other recorded the area close to the entrance. The cameras had a remote-controlled angling and zooming function/ability. After camera activation in the hybrid OR, it was possible to adjust the cameras and record the procedure from a control room located away from the hybrid OR.

3.5 | Procedure selection

The selection of procedures was mainly based on patients who were recruited by convenience sampling using the following inclusion criteria (a) the patient had to be an adult (≥18 years old); (b) the treatment had to be an elective (planned and not acute) EVAR; and (c) the responsible researcher (MB) had to be available. During the period December 2014–September 2015, 20 eligible patients were invited to participate in the study and 10 of them accepted. One of the 10 patients could not be included because the video equipment malfunctioned on that specific day, resulting in nine patients being included in the current study. All patients were treated under general anaesthesia. None of the radiological interventions were converted to open surgery at the time for the video recording. Staff involved in the recorded procedures were assigned to the procedure using normal staff routines by the nurse manager who was responsible for staffing allocation.

3.6 | Data collection

The nine patients scheduled for the procedure in this study were admitted to the vascular surgery ward the day before the EVAR intervention, and one of the researchers (MB) visited them to inform them about the study and provide written information. On the morning of the EVAR interventions, the researcher met the patients again and collected the signed informed consent. All staff had received oral and written information about the study and about the video recordings in advance. Oral information was repeatedly given during different staff meetings, and the staff had the opportunity to raise questions directly or by contacting the head of the department or the researcher. Before commencing the video recording, a large sign stating "Recording in progress" and written information about the study was placed on the entrance door to the hybrid OR. The video cameras were then activated, and the researcher moved to a distant control room and to follow and record the procedure on two screens. Recording started when the patient was wheeled into the room and ended when the patient was wheeled out of the room.

3.7 | Ethical considerations

The Regional Ethical Review Board approved this study (No. 392-14), and it was approved by the hospital management, including the heads of all participating departments. Individual written consent to video-record the procedures was received from all observed EVAR patients although they were not themselves the target of the study. Due to the high traffic flow of unexpected staff, it was not possible to collect individual written consent from staff and visitors. This was handled by giving repeated oral and written information to all staff, detailed signage when video recording was planned and ongoing and the opportunity to contact the department manager to refuse to participate.

3.8 | Data analysis

The total video recording time was 48 hr and 39 min. A brief review was made as a first step of the analysis where all videos were jointly watched and field notes were made by three of the authors (MB, SML and IB) who have various clinical backgrounds and experience in observational studies. After discussion between the three researchers, an agreement about considering the procedures in the hybrid OR as having four separate phases was decided. This division was based on the different activities that occurred in different parts of the procedure. The separate phases were demarcated by clear breakpoints (breaking points, cut-off points) illustrated in Figure 2. The first phase covered the period from the patient arrival through the entrance door until the patient was intubated. Phase 2 started after the patient was intubated and ended when the operator started the skin incision. Starting the skin incision initiated phase 3, which lasted

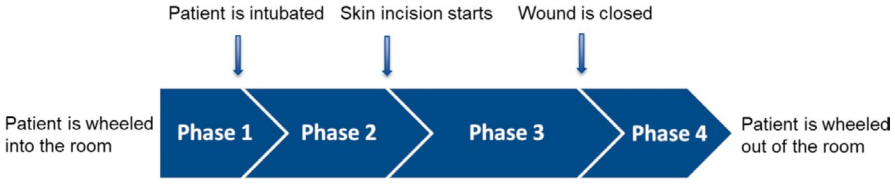

FIGURE 2 Illustration of the treatment divided into the four phases with an indication of the break point that separated each phase

TABLE 1 Duration in minutes of the four phases as analysed on the videos

Video	Phase 1	Phase 2	Phase 3	Phase 4	Recorded time
1	25	69	214	18	326
2	64	57	119	46	283
3	25	84	164	43	316
4	54	88	108	43	293
5	22	82	244	40	388
6	21	74	330	27	452
7	17	87	151	32	287
8	20	89	160	24	293
9	21	83	153	24	281
Total					2,919 (48 hr 39 min)

until the wound was closed. The final phase (phase 4) was defined as the time in-between wound closure and patient discharge from the room.

The videos were again jointly observed by two of the authors (MB and SML), who took notes separately using an observation protocol that included the number of people in the room and their title/staff category. This was done by taking snapshots every 10 min for each of the nine videos, resulting in a total of 293 observation moments where the videos were paused and notes were taken. The staff categories involved in the procedure were the following: anaesthesiologist, nurse anaesthetist, assistant nurse anaesthetist, vascular surgeon, OR nurse, OR assistant nurse, interventional radiologist and radiographer. In cases when people could not be identified as any of the mentioned categories, they were coded as others. The observation protocols from the two researchers were compared for consistency. In cases when differences were found, the videos were replayed until a consensus was achieved.

When working on their own areas (the traditional OR room and the radiological intervention room), the OR nurse and the radiographer have similar roles when assisting the operator (vascular surgeon/interventional radiologist). Because of the similarities in those roles, a further review of the videos was made by two researchers (MB, SL) to calculate and compare the time they were involved in the procedure. The time involved in the procedure was defined as the added times (duration) of wearing a sterile gown. A protocol was constructed where each researcher noted independently the time the sterile gown was put on and taken off. The two protocols from the researchers were compared and, in cases where the noted times differed, the average time for the two values was chosen.

3.9 | Validity and reliability

Descriptive statistics of observations from the nine video-recorded EVAR procedures were used in this study. Despite the limited number of recorded cases (nine), the total amount of observations was extensive, suggesting that the study material was sufficient. Moreover, an advantage of the study was that findings through the eyes of several observers were consistent through all cases. The quality of the cameras and videos and the ability to record from two angels strengthened the study. Adding field notes that were taken when the videos were observed, supports the results of the quantitative data. The video recordings made it possible to check the data and findings by re-watching the videos when necessary to ensure inter-viewer accuracy. The presence of cameras in the room may have had an impact on staff behaviour, thus limiting the internal validity of the study. However, the literature gives little evidence for altered behaviour due to camera presence (Themessl-Huber et al., 2008).

4 | FINDINGS

4.1 | The EVAR procedures

The recorded duration of each video and duration of each phase are presented in Tables 1 and 2. Phase 1 was usually the shortest and of similar length to phase 4. Phase 1 varied in time depending on individual needs for preparation, such as insertion of a central venous catheter or spinal/epidural catheter before anaesthesia. This was confirmed by a field note from video 2 where: “the patient was asked to turn over in a lateral position on the OR table for placement of an epidural catheter.” The phases with the smallest time variation were 2 and 4. The preparation periods (phases 1 & 2) were in some videos equivalent to phase 3 and sometimes longer than phase 3 (videos 2 & 4, see Table 1). Phase 3 was the longest in duration of all the phases. However, the variation in duration of this phase was largely dependent on the extent and complexity of the treatment. The total length of the procedure (phases 1–4) was mainly affected by the duration of phase 3.

4.2 | Number of people in the hybrid OR

These results are presented as the median number of people in the hybrid OR for each phase of the procedure. The room had most staff attendance during phase 3, which was when the actual intervention was being performed. Approximately eight people were present in the room during phase 3 (Figure 3). The presence of others (not shown in Figure 3) was also highest in phase 3 even though the difference was small compared with other phases. The highest number of others was correlated with the highest total number of staff in phase 3. This was highlighted in video 2 and was supported by the field note: “Five people not involved in the procedure are standing behind a radiation protective shield close to the entrance with arms crossed, watching the procedure and later moving to the 'image processing area'.” The lowest number of people in the room was in phase 1, which was the time before the patient was anaesthetized. The number of people during phase 2 was comparable to that of phase 4. The highest number of people in the OR in phase 2 was 14. This

could be explained by the following field note: "Difficulties in placing the peripheral venous catheter resulted in the presence of further anaesthesia staff" (video 2).

4.3 | Staff presence in the hybrid OR

The category (title) of present staff in the hybrid OR during the EVARs is illustrated in Figure 4. Figure 4 covers only the staff with a function and involvement in the patient and procedure. The results show that some staff categories were present in the room for the whole procedure while some people were only present for part of the procedure. Three staff categories were present in the room for the whole procedure (phases 1–4): the nurse anaesthetist, the OR nurse and the OR assistant nurse. The radiographers usually entered the room just before the start of phase 2 and left the room during phase 4. The assistant nurse anaesthetist was visible in the room for a short time during patient arrival and discharge. The anaesthesiologist was present in the room during phases 1 and 4 while the operators (vascular surgeon and interventional radiologist) were present mainly in phase 3.

Most people in the room during all phases were from the RN category. There were always one OR nurse, one OR assisting nurse and at least one nurse anaesthetist present in the room during all phases of the procedures (Table 3). The mean number of RNs (approximately 5) was highest in phases 2 and 3. Usually, the radiographer category showed up in phases 2 and 3 and there were always two of them present during these periods of the interventional procedure. The entering of the two radiographers was confirmed by the field note: "The two radiographers entered the room and had a trolley with different material on it, where after they greeted the other staff." Phase 2 engaged all RNs and assistant nurses where patient positioning became a subject for discussion, and the priorities of the staff were expressed in the following field note: "The radiographer wanted to place the arms of the patient so that the radiological equipment could rotate around the patient. This position made the nurse anaesthetist react because it would cause a loss of the monitoring curve and the OR nurse was very diligent trying to prevent the radiological equipment from coming into contact with the sterile area."

TABLE 2 Median, interquartile range (IQR) and range for the whole and phases of the procedures

	Median in minutes	IQR	Range in minutes	
			Min	Max
Recorded time	293	72	281	452
Phase 1	22	19	17	64
Phase 2	83	16	57	89
Phase 3	160	94	108	330
Phase 4	32	19	18	46

4.4 | The roles of the RNs

Phases 2 and 3 lasted the longest in terms of time (Table 1). As shown in Table 3, the number of RNs was highest in phases 2 and 3. The role of the nurse anaesthetist was described from a field note: "The nurse anaesthetist actively monitored the patient, documented and noted silent alarms from the anaesthesia equipment." The nurse anaesthetist was close to the patient in all phases. All RNs were not directly involved in the treatment of the patient in all phases, however. This was most obvious in phase 3, which started with the skin incision, where a field note indicated how the OR nurse and one of the radiographers shifted the role of being in sterile gown: "When it was time for the OR nurse to take off the sterile gown, one could see how the radiographer started to put on a sterile gown. They switched places to be closest to the patient." This shifting being in a sterile gown is presented in Figure 5. Figure 5 shows to what extent the OR nurse and the radiographer were involved in the EVAR procedures. The largest difference in time with being in a sterile gown for the OR nurse and radiographer could be seen in phase 3. The radiographer

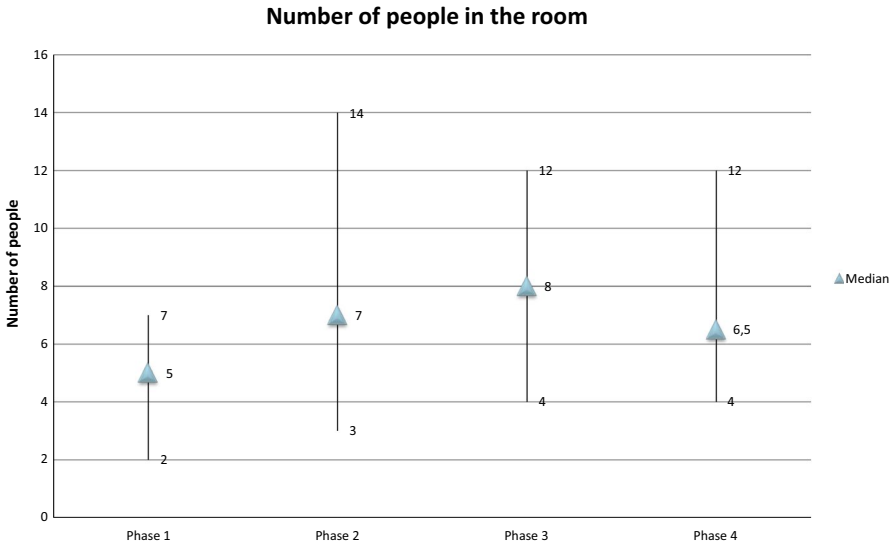

FIGURE 3 Median, minimum and maximum number of people in the room during each phase of the endovascular aortic repairs

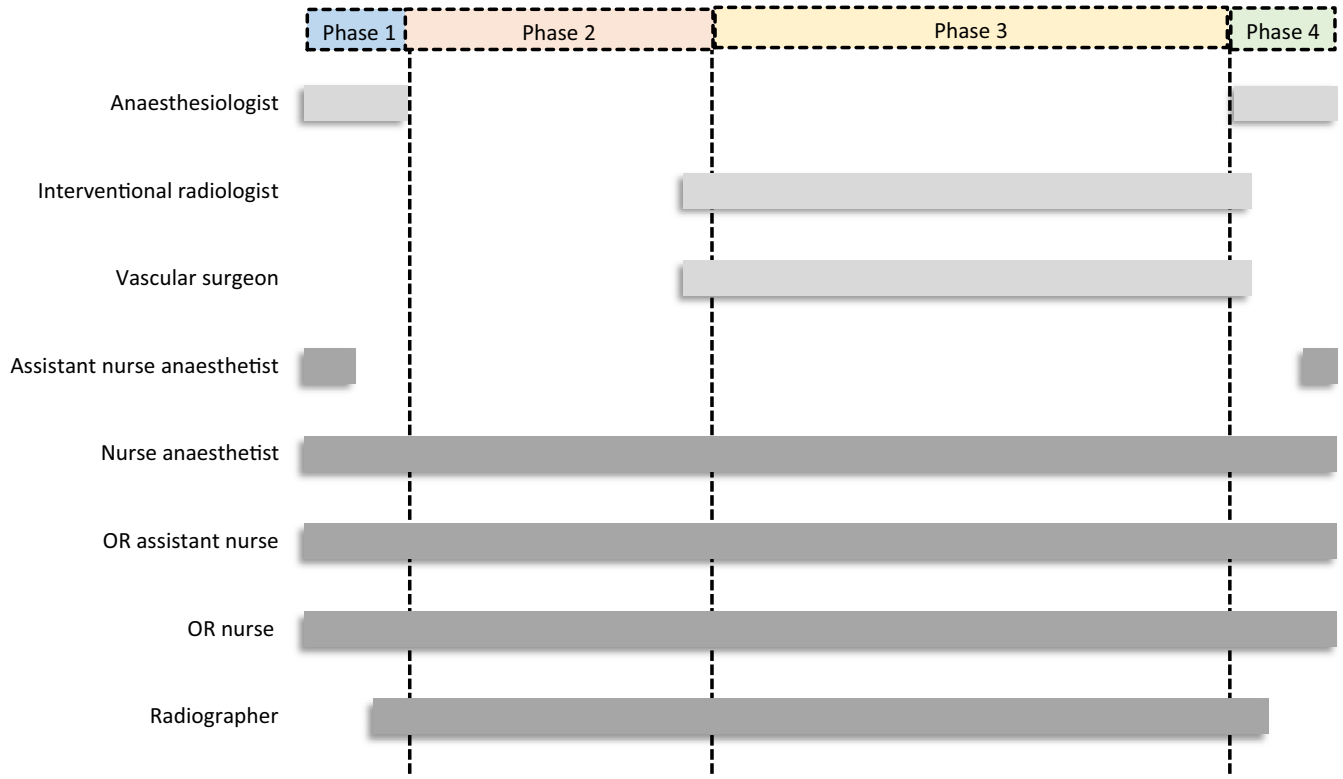

FIGURE 4 The presence in the hybrid OR of at least one representative of the different staff categories in the respective phases of the procedure. The RNs (nurse anaesthetist, OR nurse and radiographer) are further analysed in Table 3

assisted the operators throughout phase 3 while the OR nurse had a standby position in the "surgery area" (Figure 1). That was supported by field notes describing that "One or two OR nurse/s was/were standing/sitting behind a desk in the surgery area (Figure 1) talking with a colleague or looking at the computer."

TABLE 3 Median (min–max) number of RNs present in the hybrid OR in each phase of the procedure based on observations of the videos at each 10 min

	Phase 1	Phase 2	Phase 3	Phase 4
OR nurse	1 (1–2)	1 (0–2)	1 (0–3)	1.5 (1–3)
Nurse anaesthetist	2 (1–3)	2 (1–3)	1.5 (0–2)	1 (1–3)
Radiographer	0 (0–2)	2 (1–3)	2 (1–3)	0 (0–3)
Total	3 (2–7)	5 (2–8)	4.5 (1–8)	2.5 (2–9)

5 | DISCUSSION

5.1 | Discussion of findings

5.1.1 | Team composition and number of people in the room

In this study, the maximum number of people in the hybrid OR was 14, which matches the findings of Zheng, Panton, and Al-Tayeb (2012) in a traditional OR. The median number of people in the hybrid OR was five in phase 1 and approximately eight in phase 3. This could possibly be an underestimation because people located in the image processing area (Figure 1) were not visible on the videos. Estimated staff requirement calculations have proposed that up to 20 people may simultaneously be required in the hybrid OR during a complex endovascular intervention (Eder & Register, 2014). The high number of staff involved indicates the complexity of the interventional procedure. However, this increase in expertise means an increase in the size of the team, which may create team communication barriers (Sykes, Gillespie, Chaboyer, & Kang, 2015) and prolonging of the procedure (Zheng et al., 2012). Keeping the number of people in the room low during phase 1 is important to provide integrity and a comforting atmosphere for the patient who is still awake at this stage (Blomberg, Bisholt, Nilsson, & Lindwall, 2015; Kelvered, Ohlen, & Gustafsson, 2012). Our study showed that the hybrid OR was most crowded during phase 3 when the wound was open and the endovascular procedure was being performed. Traffic flow, which is associated with the risk for postoperative infections (Bedard, Pelletier-Roy, Angers-Goulet, Leblanc, & Pelet, 2015), was also judged to be high and largely avoidable (Katz, 2017). Beyond the high number of people during phase 3, our analysis showed that in this specific phase of the procedure, the work was restricted to a few number of staff categories while the rest of the attending people were less active or not at all involved in the patient care. A high number of people in the room could occasionally be related to moments when the staff shifted to cover each other for breaks, but that did

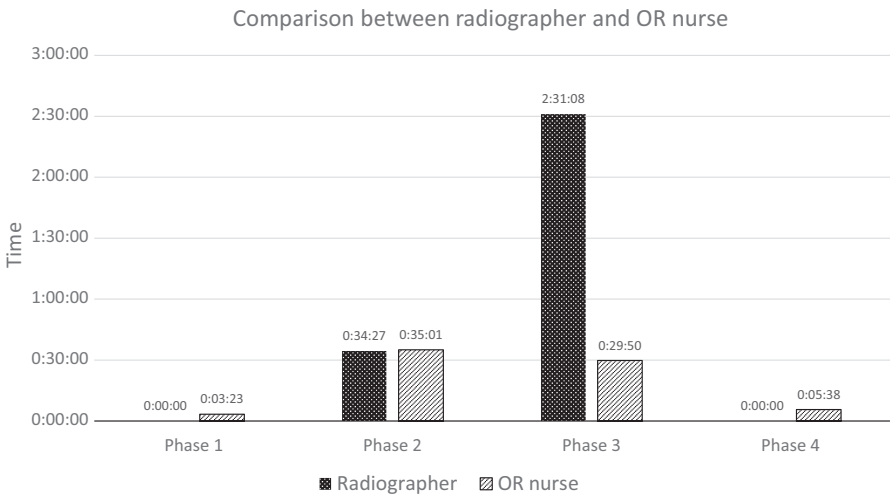

FIGURE 5 Average time wearing the sterile gown on for the radiographer and OR nurse in each phase of the EVAR procedure

not occur for the radiology staff. Surgery disruptions associated with shift changes/breaks contribute to errors that are considered preventable (Palmer et al., 2013). The presence of others was also the highest in phase 3 and is likely related to the presence of students and other visitors in this large teaching hospital setting. However, this was not specifically analysed in this study. In the planning and building process of the hybrid OR, this was considered, and an audit room was built for that purpose for student observers. However, this room was not used during the procedures in this study. An additional factor contributing to the number of people in the hybrid OR may be the presence of staff in training, who were under supervision at the time of the study. An alternative and perhaps preferable way of training staff is to do it in a simulated OR environment (Vincent, Moorthy, Sarker, Chang, & Darzi, 2004; Wong, Smith, & Crowe, 2010). In some cases, the presence of "others" may be related to the attendance of technical staff or technical vendor representatives checking the equipment. The present study did not specifically evaluate the reasons for entering the hybrid OR, but earlier studies performed in traditional ORs showed a high number of door openings related to social visits with no detectable reasons (Andersson, Bergh, Karlsson, Eriksson, & Nilsson, 2012). A change in the OR culture at an organizational level is suggested to reduce traffic flow and lengthening of the wound exposure (Andersson et al., 2012).

5.1.2 | Staff categories in the room

The procedures in this study varied greatly in duration mainly due to the differences in time length in phases 1 and 3. These differences could be related to differences in the complexity of the procedures (Sykes et al., 2015). Due to these variations, no more than one patient a day could be scheduled in advance. The variety between the EVAR procedures also implies that the staff involved have to be flexible, have a broad knowledge of different procedures and be able to react adequately to possible changes in the treatment plan, such as conversion into open surgery (Desender et al., 2017).

It was noticeable that some staff categories were present the whole time while "others" were present in the room for short periods when needed or having an active role. One question that arises is if all staff need to be present in the room during the periods they are not directly involved in the procedure, particularly in the face of specialist staff shortages and an interest in using staff as effectively as possible. A contrasting question is whether the continuity and responsibility for the overall patient care may be lost if the staff categories are present in the room only when needed.

The assistant nurse anaesthetist was present in the room during short periods when patients arrived (phase 1) and were discharged (phase 4). Even if the assistant nurse anaesthetist was only in the room for short periods during patient transfer (Figure 4), one can question if this staff category has to be in the room at all. The anaesthesiologist was present in the room mainly during phases 1 and 4 (in connection to anaesthesia induction and when the patient regained consciousness). The nurse anaesthetist was, on the other hand, present in the room during the whole procedure, monitoring the patient. The radiographers were rarely in the room during phases 1 and 4, similar to the operators (vascular surgeon and interventional radiologist). Usually, two radiographers were present in the room during phases 2 and 3. One was responsible for the sterile parts of the procedure and the other for the non-sterile parts of the procedure handling technical parts, such as the contrast injector and imaging equipment and assisting the sterile-dressed radiographer. The OR assistant nurse who was present in the room almost during the whole procedure had a similar assisting role, which raises the question whether the assisting tasks could be combined and assigned to one staff category. Another question is whether the OR nurse and the radiographer could identify common tasks and responsibilities to collaborate more.

5.1.3 | RNs in the room

There was a high number of RNs during phases 2 and 3 and of these, at least one nurse anaesthetist was close to and monitoring the patient throughout the entire procedure. According to our results, an additional nurse anaesthetist (Table 3) was usually present in most phases, but that person's role could not be clearly defined. As mentioned

previously, several staff categories shifted for breaks and during the shift, more than one of the same staff category was present in the hybrid OR. However, this may not completely explain the number of nurse anaesthetist in the room. The roles of the OR nurse and radiographer differed in different parts of the procedure. The most obvious difference was during phase 3 where the radiographer's role was extensive compared with the role of the OR nurse who mostly had some type of standby position/role (in case of open surgery). Besides being inefficient, it can be questioned if the specialists were used in an adequate way. At least one OR nurse was present in the room during the whole procedure (phases 1 through 4), but he/she was mainly involved in the aseptic and hygiene processes of the procedure (e.g., preparing sterile material, sterile draping of the patient, cleaning, dressing the wound and cleaning the room). Maintenance of a sterile field should, however, be a responsibility shared by all team members (Chan et al., 2012).

The hybrid OR is a complex environment, and the greatest threat to the sterility of environment is human rather than technically related failures (World Health Organization, 2009). The composition of the team, including the number and categories of staff and their roles, is important issue for patient safety reasons. A team where the members are familiar with each other promotes both patient safety but also team performance (Gillespie, Chaboyer, Longbottom, & Wallis, 2010). Since OR teams are usually composed ad hoc, further studies are needed to investigate other factors that promote team performance and patient safety in the setting of hybrid ORs.

5.2 | Limitations

One limitation of the study was that a small part (image processing area) of the hybrid OR was not visible on the videos due to restriction of the camera angles. Thus, the number of people in the room may be underestimated. Another limitation was that the time involved in the procedure was calculated only for two roles in the room: the OR nurse and the radiographer. Including the second present radiographer in the room and the OR assistant nurse would have given more information about the roles in the hybrid OR. The way of defining the time of involvement for the OR nurse and radiographer can be questioned since wearing the sterile gown does not necessarily mean involvement in the procedure. However, the measure is considered to be relevant especially when it was strengthened and confirmed by field notes showing how the two staff categories switched position by being nearest to the patient. Data for this study were gathered from one specific hybrid OR where usually the same set of staff worked and thus generalization may be difficult. Despite these limitations, we believe that the results from this study could be applicable in other similar settings where staff categories with similar and overlapping roles work together.

6 | CONCLUSION

This study showed that a complex hospital environment, such as a hybrid OR, requires several specialist competencies, but the specialists were not used optimally. One question raised by our findings was if all professions have to be in attendance in the hybrid OR during the whole procedure since there were several episodes of extended inactivity. Better coordination and clarification on how to handle overlapping roles for the RNs would also be a consideration based on the findings. Additionally, some of the people who were present were not involved in the treatment or care of the patient and as such, their presence in an OR that is meant to be as aseptic as possible should be scrutinized. Earlier studies in traditional operating rooms have highlighted traffic flow and the number of people in the room during surgery as problematic and this also seems to be a problem in the hybrid OR. Future studies that further illuminate the optimal team composition and required professional competencies during an interventional procedure in a hybrid OR should be conducted since this field is, to the best of our knowledge, largely unexplored. Future studies should also focus on the amount of, reasons for and effects of door openings in a hybrid OR.

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CONFLICT OF INTEREST

No conflicts of interest.

AUTHOR CONTRIBUTIONS

MB, SML and IB made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data and involved in drafting the manuscript or revising it critically for important intellectual content; MB, SML, IB, KA, IF and MH given final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

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