

Patients and Staff in the Hybrid Operating Room

Experiences and Challenges

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Institute of Health and Care Sciences
Sahlgrenska Academy, University of Gothenburg



UNIVERSITY OF GOTHENBURG

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Cover illustration: Dario Soltani. The patients' descriptions of the hybrid OR in Study I are shown in the puzzles.

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ABSTRACT

The hybrid operating room (OR), which combines a traditional OR with a radiological intervention room, is one example of the technical advancements within hospitals. In a hybrid OR, the staff have to manage the technique confidently in a not completely familiar environment and still be able to care for the vulnerable patient in the safest way. The overall aim of this thesis was to explore and describe the care and work processes, staff interactions, and experiences of both patients and staff in the hybrid OR. Data were collected through 18 individual interviews, nine video recordings of endovascular aortic repairs (EVARs) and five focus group interviews. Data were mainly analyzed qualitatively (hermeneutic, hermeneutic phenomenology and qualitative content analysis) but also with the use of descriptive statistics. The environment in the hybrid OR was experienced as safe by both patients and staff. The patients felt cared for, but a distance to the staff was also evident in the hybrid OR. Moreover, patients expressed an unpredictability mostly related to the time after surgery. The extensive safety preparations, which prolonged the procedures, were evident for the staff. The nursing staff from anesthesia, surgery, and radiology enjoyed working in the hybrid OR but declared that collaboration was largely dependent on individual personalities. The work took place in several separate rather than in one cohesive team

and there was also a lack of joint meetings before and after the procedures. Waiting times and uneven division of labor were considered to obstruct collaboration, and also affected the workflow. Some of the nursing staff's responsibilities, for example the one for communicating with the patient, were found not to be completely clear. Several of the patients' worries could be preventable with better provided information and communication with the patient throughout the care process. Alternative compositions of the team and better distribution of the responsibilities would likely make the procedures more effective and probably result in higher staff satisfaction. A need for seeing the procedures and the team as a whole was evident and could be improved by team training, education, and team meetings before and after each procedure. An openness to, and insight into, each staff category's competence would likely improve the interprofessional trust of the team in the hybrid OR.

Keywords: hybrid operating room, patient experience, nursing staff, endovascular aortic repair, teamwork, video recordings, interviews, radiology, surgery, anesthesia

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SAMMANFATTNING PÅ SVENSKA

En hybridsal är en kombination av en traditionell operationssal och en radiologisk interventionssal och ett exempel på den teknologiska utvecklingen inom sjukvården. Arbetet i en hybridsal kräver att personalen i en inte helt bekant miljö kan hantera tekniken och samtidigt vårda den sårbara patienten på ett säkert sätt. Det övergripande syftet var att utforska och beskriva vård- och arbetsprocesser och personalinteraktioner i en hybridsal samt att undersöka patienters och personals upplevelser av en hybridsal. Databesamlingen skedde under perioden november 2014 - juni 2016 och bestod av 18 individuella intervjuer (Studie I), nio videoinspelningar av endovaskulära aortaaneurysmbehandlingar (EVARs) (Studie II och III) samt fem fokusgruppsintervjuer (Studie IV). En hermeneutisk analys genomfördes i Studie I. Studie II analyserades med hermeneutisk ansats och ett typfall/paradigmfall skapades. Studie III analyserades med deskriptiv statistik och Studie IV med hjälp av kvalitativ innehållsanalys. Patienterna upplevde miljön som trygg och säker trots den omfattande närvaron av teknisk utrustning och personal från olika specialistområden. Patienterna kände sig väl omhändertagna i hybridsalen men upplevde en viss distans till personalen. Patienterna beskrev att de var oförberedda främst gällande den påfrestande tiden som följde efter operation. De omfattande säkerhetsförberedelserna, som förlängde proceduren, belystes av sjuksköterskeprofessionerna i Studie IV men var också märkbara i Studie II och III. Vårdpersonalen inom anestesi, kirurgi och radiologi trivdes med arbetet i hybridsalen men förklarade att arbetet skedde i flera separata team och att samarbetet till stor del var personbundet. Det förelåg också en brist på gemensamma avstämningar före och efter proceduren. Väntetiderna mellan olika delar av behandlingen och den ojämna arbetsfördelningen ansågs också vara ett hinder för samarbetet och det påverkade också arbetsflödet. Sjuksköterskeprofessionernas olika ansvarsområden, exempelvis gällande kommunikationen med patienten, var inte helt tydliga. Mycket av patienternas oro skulle kunna förebyggas genom bättre information till och kommunikation med patienten genom hela vårdprocessen. Alternativa teamsammansättningar och fördelningen

av arbetsuppgifter skulle möjligen göra procedurerna mer effektiva och möjligen leda till högre arbetstillfredsställelse. Det finns ett behov av att se proceduren och teamet som en helhet och detta skulle kunna åstadkommas med exempelvis teamträning, utbildning samt regelbundna teamsammankomster före och efter varje procedur. En öppenhet för och insikt i varandras professioner skulle förmodligen öka tilliten mellan de olika personalkategorierna.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

- I. Bazzi, M.; Lundén, M.; Ahlberg, K.; Bergbom, I.; Hellström, M.; Lundgren, S.M.; Fridh, I. Patients' lived experiences of waiting for and undergoing an endovascular aortic repair in a hybrid operating room: A qualitative study. *Accepted for publication in Journal of Clinical Nursing*, 11/10/2019.
- II. Bazzi, M.; Lundgren, S.M.; Hellström, M.; Fridh, I.; Ahlberg, K.; Bergbom, I. (2019). The drama in the hybrid OR: Video observations of work processes and staff collaboration during endovascular aortic repair. *Journal of Multidisciplinary Healthcare*, 12, 453-464.
- III. Bazzi, M.; Bergbom, I.; Hellström, M.; Fridh, I.; Ahlberg, K., Lundgren, S.M. (2019). Team composition and staff roles in a hybrid operating room: A prospective study using video observations. *Nursing Open*, 6(3), 1245-1253.
- IV. Bazzi, M.; Fridh, I.; Ahlberg, K.; Bergbom, I.; Hellström, M.; Lundgren SM.; Lundén, M. Collaboration in the hybrid OR: A focus group study from the perspective of the nursing staff. *Manuscript*.

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ABBREVIATIONS

OR	Operating room
EVAR	Endovascular aortic repair
TEA	Thrombo-endarterectomy
MRI	Magnetic resonance imaging
RN	Registered nurse
BoIC	Swedish Bild och Interventionscentrum = Imaging and intervention centre
ECTS	European credit transfer system

DEFINITIONS IN SHORT

C-arm	A fluoroscopy X-ray system used for a variety of diagnostic imaging and surgical procedures
Fluoroscopy	Imaging technique that uses X-rays to obtain real-time moving images of an interior object/body
Hybrid	Something that results from the combination of two different elements
Interventional radiology	A medical specialization which provides minimally invasive image-guided diagnosis and treatment of disease
Operator	A physician with specialization in either vascular surgery or interventional radiology
Perioperative period	The time periods immediately before, during and following a surgical procedure
Team	A group of people that work together towards the same goal

INTRODUCTION

This thesis illuminates a new care and working environment and highlights the perspectives of both patients and nursing staff when they face a new and technology intense hospital environment. Healthcare is becoming more and more complex, specialized and technological and the use of technology is expected to support healthcare staff for treating patients in the best and most secure way. Collaboration between several healthcare specialties becomes more common and is essential in order to reach up to optimal healthcare with maximum utility of staff, facilities and technical equipment. In the Western region of Sweden, a major investment has been made when the construction of a so called Imaging and Intervention Centre (Swedish Bild- och Interventionscentrum (BoIC)) recently got completed (year 2016). This center is a five floor building that includes highly specialized departments including surgery, radiology, anesthesiology, and nuclear medicine with the regions' first cyclotron for medical tracers, allowing advanced PET-CT examination (Leth et al., 2008). The BoIC also comprises modern operating rooms (ORs) named hybrid ORs, where both open surgery and interventional radiology are possible in one and the same room. One of the hybrid ORs in BoIC is the first in the Nordic countries with magnetic resonance imaging (MRI) equipment. The main intension with and profits of hybrid ORs is the opportunity to perform both minimally invasive procedures by guidance of radiological imaging techniques and open surgery. There are further suggested benefits with hybrid ORs apart from the medical and treatment abilities. When different procedures can be performed on a patient in one and the same room, an increased patient safety is expected by avoiding risky transportation of the patient, and it may also lead to a shorter overall hospital stay (Sikkink et al., 2008).

My interest as well as my pre-understanding for the topic of this thesis includes both working clinically as a radiographer and teaching in the radiography nursing program at the University of Gothenburg. During my employment as a lecturer, planning for and construction of BoIC were in progress and a lot of discussions took place about how to staff the building and both teach and prepare the staff for the new

environment. Among other things, the clinics requested both internal (at the hospital) and formal (academic) education by initiation of post graduate level courses and customization of the existing educations. A clinically fully useable prototype hybrid OR was built in an already existing surgical department and the ambition was to learn from the experiences by working there and transfer the knowledge and experiences to the upcoming hybrid ORs in the BoIC. This inspired and motivated the planning and design of the studies included in this thesis.

BACKGROUND

HEALTHCARE ENVIRONMENT

The starting point for this thesis is that changes in any physical environment, such as new buildings and rooms for care and treatment, have an impact on the people who are intended to utilize it. The relationship between the environment and person has been recognized since the beginning of medicine as a field (Ulrich et al., 2008). Hippocrates believed that the body possessed its own means of recovery, and it was important to aid the body's own forces by harmonizing the individual, social, and natural environments (Kleisiaris et al., 2014). Florence Nightingale (1820-1920) noticed that some of the symptoms and discomfort experienced by the patient were associated with the environmental shortcomings rather than with the disease itself (Nightingale, 1992).

There are different concepts that can be used when describing the environment within healthcare settings (Edvardsson, 2005). In this thesis, the healthcare environment refers to both the physical, psychosocial, and cultural atmosphere and how they affect both patients and staff. Edvardsson (2005) used the conceptual atmosphere for describing the care environment by the staff's way of being (e.g. how they moved around and, how they spoke, approached, and touched the patients), which contributed to the experiences of the atmosphere. The healthcare environment can also be described from the concepts of place and space. Places are not only containers for people's activities but the result of complex interactions (i.e., people "make" places, and the places make the people and can affect them (positively or negatively). The concept of place relates to location and spatiality, whereas space relates to how people experience the meaning of places that they inhabit (Lindahl & Bergbom, 2015).

Regardless of definition and use of concept, there is strong evidence that the healthcare environment can have a positive impact on both patients and staff (Stichler, 2009). A favorable physical environment or design can, for example, contribute to reduced stress, increased work efficiency, improved patient safety, and generally better quality of care

(Joseph & Rashid, 2007; Ulrich et al., 2008). The purpose of a hospital building is to offer a place of protection for people and their activities (Lindahl & Bergbom, 2015) and should serve as safe places and work environments for patients and staff, respectively (Stichler, 2009). A healthcare environment should also be safe and attractive to staff to reduce stress and high turnover.

THE HYBRID OR

Changes in the environment and technique may not only increase safety risks for the patient but also frustration for the staff if they are not able to master the technique. In a highly technological environment, it is important for the staff to have the ability to balance between the use of the technique and caring for the patient (Bergbom, 2014). The hybrid OR, which is the context of this thesis, is a new combination of two complex environments; the OR and the interventional radiology suite. It is an example of the technological advancements within hospitals. The term *hybrid* means “something of a mixed origin or composition” or “something that results from the combination of two different elements” (Murakami, 2018, p. 57). The integration within a hybrid OR may differ according to the literature but some shared similarities that define a hybrid OR do exist. First of all, the room usually has imaging capabilities not limited exclusively to a C-arm, as that is usually available in a traditional OR. The imaging capabilities should make it possible to perform catheter-guided radiological intervention procedures, and some of the modern hybrid ORs also include magnetic resonance (MR) cameras. The presence of heavy technological equipment entails that the room has to be larger than a traditional OR and a size of at least 80 m² is recommended (Gofrit et al., 2016). A higher number of staff with various specialties is usually needed during a procedure in a hybrid OR. An estimated staff calculation suggests that up to 18 people may simultaneously be needed in the hybrid OR (Nollert et al., 2012). Moreover, the hybrid OR is a tailored solution based on the needs of each hospital, and the room layout and available equipment can, therefore, differ (Kpodonu, 2010) and be located in different physical spaces within a hospital (Ashour et al., 2016).

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The hybrid OR provides both optimal imaging capabilities and fulfils the hygienic requirements for an open surgery (Sikkink et al., 2008). The possibility to treat the patient with both interventional radiology and open surgery in the same room not only makes the process more effective but also decreases for instance the infection risks that are associated with patient transfers between room and departments (Knudson, 2012; Ulrich et al., 2008). Further potential benefits for the patients with a hybrid OR are quicker recovery time (Knudson, 2012), shorter hospital stays, and higher patient satisfaction (Field et al., 2009).

In the literature, hybrid ORs are investigated mainly from a medical and technical perspective. Treatments that could benefit from being performed in a hybrid OR include vascular procedures (Tsagakis et al., 2013), neurovascular procedures (Iihara et al., 2013), thoracic surgeries (Terra et al., 2016), and trauma surgeries (D'Amours et al., 2013; Richter et al., 2015). The radiation doses that are associated with treatments performed in hybrid ORs have been evaluated, and the results are mixed. For example, a study by Andres et al. (2017) showed that patient and staff radiation doses within the hybrid OR context were not considered a major problem. However, results from another study showed the opposite and regarded the radiation exposure to vascular surgeons as a serious concern of this new type of OR (Attigah et al., 2016). Possible disadvantages with the hybrid OR are not clearly described in the literature but the most commonly mentioned drawback appears to be room construction cost (Nollert et al., 2012). Elevation of infection risks due to a potentially higher number of people in the room together with a prolonged general anesthesia time have also been mentioned as possible disadvantages of a hybrid OR (Field et al., 2009). The research within OR environments is mainly design-focused and should include its influence on patients and staff (Joseph et al., 2018). If and how the environment of the hybrid OR impacts the patients and staff is a lacking dimension in the literature and, therefore, the subject for this thesis aims to fill these gaps in research.

ENDOVASCULAR AORTIC REPAIR

An endovascular aortic repair (EVAR) is a method for treating aortic aneurysms, which is a common disease in the over 60 years old male population (Patel et al., 2016). The prevalence of abdominal aortic aneurysm is 1.5-2.0% in Sweden in men who are 65 years or older. In 2016 in Sweden, of all the aortic aneurysms, only 17% were experienced by women while 83% were experienced by men (Swedvasc, 2017). The choice of performing an EVAR over other treatment options, such as open surgery, depends on different patient characteristics and general condition, the location of the aneurysm but also local routines and differences can be found between hospitals within the same country on which procedure is used (Quintana et al., 2019). However, in Sweden, EVAR treatments have increased successively. In 2017, approximately 60%, compared to 53% in 2016, were treated with EVARs compared to other treatment methods (mainly open repairs/surgeries) (Swedvasc, 2016). Converting from EVARs to open repairs during the procedure is rare. According to the vascular registry in Sweden (Swedvasc, 2016), only 0.3% (25 patients) during 2016 had to convert from EVARs to open repairs. EVARs may be performed with different types of anesthesia - general, local, or regional - and the choice depends for example on whether the treatment is acute or elective but also on local expertise and traditions (Armstrong et al., 2019). However, there is an increased trend to use local and regional anesthesia because they are considered to be as safe as general anesthesia, result in shortened surgery time, and tend to decrease the length of stay at the hospital for the patients (Cheng et al., 2019).

In Sweden, EVAR is a common procedure within the context of the hybrid OR, and was, therefore, reasonable to choose as a focus in this thesis. As EVAR procedures became more complex, it became clear that a hybrid OR was necessary to provide optimal care for patients (Varu et al., 2013). The hybrid OR could provide multiple imaging abilities for guidance and precise definition of pathology, but it also provides the opportunity for immediate conversion to open surgical repair if needed. Sometimes, other surgical procedures, for example thromboendarterectomy (TEA), may be needed together with an EVAR, and a

hybrid OR offers the possibility to perform these hybrid procedures. A hybrid procedure means “a major procedure that combines a conventional surgical part including a skin incision with an interventional part using some sort of catheter-based procedure guided by fluoroscopy without interruption” (Nollert et al., 2012, p. 73). As mentioned previously, image guidance within a hybrid OR is not necessarily limited to fluoroscopy and angiography. It can also include ultrasonography and, in some institutions, magnetic resonance imaging (MRI; (Nollert et al., 2012)).

BEING A PATIENT IN THE HYBRID OR

The term patient has historically been widely used, but there are discussions about using other terms, such as client, customer, and consumer (Salmela & Nystrom, 2017). In this thesis, however, the term patient is preferred and used. The term patient is defined from its original meaning as the suffering, which initially was not attributed to a disease but a human being that suffered and had to endure something negative (Eriksson, 1996). A human being in need of care is a patient dependent on carers (the staff), who have a responsibility for human beings who are ill and need care, and this is why the term patient is appropriate (Salmela & Nystrom, 2017). The term patient-centered care, also used in this thesis, is a complex term in nursing, and it can be defined from multiple perspectives (Marshall et al., 2012; Mead & Bower, 2000). In this thesis, patient-centered care is defined as “the provision of care incorporating contextual elements and including the attributes of encouraging patient autonomy, the caring attitudes of the nurse, and individualizing patient care” (Lusk & Fater, 2013, p. 97).

Being a patient in a hybrid OR means being faced with a highly technological environment that may have the potential to create anxiety (Haugen et al., 2009). The technology enables better treatment of diseases, but it can also decrease the physical interaction between nurses and patients (Karlsson et al., 2013; Munn & Jordan, 2011; Reeves & Decker, 2012; Sandelowski, 2002; Stichler, 2009). There were no studies that highlight the patients’ perspectives in the context of a hybrid OR. There are, however, some studies about the patients’

experiences in relation to similar technology intense environments, for example, radiological intervention rooms (Lundén et al., 2013, 2015), traditional ORs (Forsberg et al., 2015; Forsberg et al., 2018) and intensive care rooms (Johansson et al., 2012; Olausson et al., 2013; Whitehorne, 2015). Several of these studies showed high patient satisfaction but also areas of improvements. For example, information needs and the opportunities to participate in decisions about the care in the perioperative period were found as the main areas for improvements in the study by Forsberg et al. (2015). Also, in a study by Lundén et al. (2015), having more information and being provided with more knowledge about the procedure were seen as important in order to avoid unnecessary anxiety in patients.

There are also several studies illuminating the patients' experiences of different radiographic procedures where patients exhibited signs of fear. They found good communication with the radiographer to be essential in reducing fear (Andersson et al., 2008; Patatas & Koukkoulli, 2009).

The radiographer-patient interaction is often described as key when a radiographic procedure is to be performed, and this interaction has been shown to influence the patients' experiences of their care and feeling of being involved in their own care (Shattell et al., 2005; Tornqvist et al., 2006).

TEAMWORK

The complexity of the techniques in a hybrid OR requires involvement of expertise from different medical specialties (Knudson, 2012). Collaboration between professionals from different specialties has been a popular form of organization for a number of decades. Good teamwork is considered to improve medical outcomes, procedure efficiency and patient safety. While the terms team and teamwork are well used both orally and in writing the description of healthcare teams is still considered to be incomplete (Tremblay et al., 2017; Xyrichis & Ream, 2008). The common assumption is that teamwork in health care is a dynamic process characterized by consensus, cooperation and interdependency (Finn, 2008; Xyrichis & Ream, 2008). In this thesis, a

BACKGROUND

team refers to a group of people that have to work together to achieve a goal, but the definition does not reveal anything about how well the team is functioning. Interprofessional collaboration is often referred to in the literature in association with team, but there is an inconsistent use of the term (Thylefors et al., 2005). Ingela Thylefors (2005) discusses cross-professional collaboration within healthcare teams, which in itself can be either multi-, inter-, or transprofessional. The prefix indicates the type of collaboration that occurs and the level of integration of the tasks, which in turn impacts team performance and effectiveness. The prefix multi (many) refers to a team with different organizational specialties where collaboration not necessarily occur. Inter (in-between) refers to a real collaboration and a mutual influence between several specialties. Trans (across) implies a collaboration across boundaries between different professions (Thylefors, 2014).

One of the difficulties described by members of a team is associated with roles when team members overstep their professional boundaries into another individual's professional territory (Kvarnström, 2008). Many nurses face interpersonal conflict and poor communication amongst colleagues, role overload, workplace stress, role conflicts, and ineffective and non-supportive management (Stichler, 2009). It is important that all members of the team understand both their own and others' roles and knowledge bases.

Teamwork within surgical environments is a well-studied area where, for instance, communication shortcomings between the team members were identified as the main reasons for adverse events (such as surgical complications) mostly related to communication failure and could therefore be avoidable (World Health Organization, 2009). Within both OR and interventional radiology, barriers to successful teamwork included competing priorities and a lack of shared mental models, which developed from a lack of experience of working together as a team (Ramaswamy et al., 2017). Teamwork within the context of a hybrid OR has not been evaluated earlier.

SHARED MENTAL MODELS

The importance of a team working toward shared goals by using a shared approach in healthcare settings has a well-established theoretical and empirical basis, and it has been found to influence the quality and continuity of patient care positively (Hustoft et al., 2019; McComb & Simpson, 2014). According to Mathieu (2000), shared mental models can be divided into task and team models, and they influence the team performance, especially in a changing environment with dynamic tasks. The task models can be related to the equipment or procedures; while the team models can either be related to the team interaction or to team specific knowledge. In shared mental models, first of all, team members must understand the equipment and technology with which they interact. Second, team members must hold shared job or task models, which revolve around how a task is accomplished in terms of the procedures. In the team mental models, members must hold a shared concept of how the team interacts where defined roles, responsibilities, interaction, and communication are understood. Furthermore, team-specific knowledge about teammates helps team members to tailor their behaviors to what they expect from teammates better (Mathieu et al., 2000). The concept of shared mental models within OR environments are important to maintain patient safety (Nakarada-Kordic et al., 2016).

NURSING STAFF IN THE HYBRID OR

Nursing staff in this thesis will be used as a term where both the registered nurses (RNs) and the assistant nurses are included. In this thesis, the main focus is on creating knowledge about the RN professions that are working in the context of a hybrid OR.

In 1952, the Swedish government noted the need of more technical education for nurses and suggested that after two years general education, the nursing students could the third year choose between specialties, such as medical, surgical, and radiography (Vårdförbundet, 2017b). Based on an EU directive, the Swedish Higher Education Act was introduced in 1992 extending nursing education to three years

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(rather than two) and to be scientifically based in healthcare (1992:1434). Today in Sweden, the nurse profession has a degree of first-cycle at a bachelor's level and has a protected title (Swedish: sjuksköterska), which means that only those who have a license to practice nursing are allowed to call themselves nurses. Specialist nursing, for example, in surgical or anesthesia care is a second-cycle program for licensed nurses, leading to a postgraduate diploma in specialist nursing and a Master of Science (MSc) in a specific area of expertise (Vårdförbundet, 2017b).

Due to the shortage of nurses specializing in radiography and the vast technological development within the radiological field, a new direct education toward radiography was implemented in 1962. It was expanded in 1964 as the radiographer was responsible for both the technology and the patient. Radiology was integrated from the start of the direct education to radiography, and the students were acknowledged as a professional entity early on. The nursing programs were at a crossroad. Should a generalist education be maintained or should they keep the specialist education toward radiography? The places in the specialist education for radiography were not filled, and there was a lack in specialized nurses in the radiology departments. This led to the direct education toward radiology encompassing 120 credits (equivalent to 180 ECTS by today's standards) being implemented in 1994 in Sweden (Vårdförbundet, 2017a).

The radiographer (Swedish: röntgensjuksköterska) profession, which has different titles, education, and practical work expertise in European countries, will be considered as an RN (registered nurse) within the area of radiology throughout this thesis. Registered radiographers in Sweden have the responsibility for both the patients and the technical equipment (Andersson et al., 2008; Niemi & Paasivaara, 2007) and are seen as members of the nurses' collective. The radiographers' medical competence is often equated with that of nurses (Stalsberg & Thingnes, 2016; Tornqvist et al., 2006). Today, the education to become a radiographer is a three-year academic program leading to a bachelor with a specialization in diagnostic radiography and a diploma as a radiographer in Sweden. They can continue to a (one- or two-year) MSc.

Assistant nurses, on the other hand, are not licensed and have a secondary vocational education with mainly practical training in various areas of care.

CARING IN THE HYBRID OR

The concept of caring is, in this thesis, considered as a core competency and responsibility for all RNs (including the radiographers), regardless of specialty. Caring (Swedish: *vårdande*) originates from human sciences, where the human being is seen as a union of body, mind, and spirit with the goal of helping the patient regain their health (Eriksson, 1996; Watson, 1985). Caring, aiming to strengthen health and relieve suffering, can be given by any of the staff (the carers) within the context of the hybrid OR (Arman, 2015). A caring attitude means being open and emotionally present to how the patients are experiencing their situations and being able to seek understanding for the patient but also in collaboration with the patient (Watson, 1985). When the carer touches the patient's body in a care or treatment activity, the mind and spirit are also considered touched in the same way as caring for a patient's spirit touches the body and mind (Eriksson, 2002). Treating the patient holistically where each patient is seen as an individual with different physical, mental and emotional problems and needs was early described as an important facet in the radiographer profession (Whyke, 1982).

A patient that is facing treatment for some disease, whether in a radiological interventional room or an OR, is dependent on the carer. The relationship between the carer and the patient is always asymmetric, meaning that the carer is in charge and one main value in caring means a responsibility to protect and preserve the patients' dignity (Eriksson, 1996; Kasén, 2002; Lindwall, 2004). The competence, professional experience, and emotional engagement are important when inviting the patient to a caring relationship. If the carer is only there physically, performing the task, the situation could be experienced as uncaring, mediating a feeling of being let down and thereby causing unnecessary suffering for the patient (Kasén, 2002).

BACKGROUND

Establishing a caring relationship is dependent on contextual aspects, and technological environments are often task-oriented and organized around the equipment rather than the patient's needs (Reeves & Decker, 2012). Whereas nursing research emphasizes the importance of taking time to establish a relationship with the patient, a key characteristic during an interventional procedure is the transient nature of the encounter, similar to diagnostic radiography procedures (Bleiker et al., 2016).

HEALTH AND CARE SCIENCES

As the environment in hospitals changes, research needs to explore how caring in these environments should emanate from the patients' and staff's perspectives. Health and care science is a theoretical and knowledge base that aims to create knowledge that can be applied in caring (i.e., theories about how to care for people that are patients, about health, human suffering and well-being, about life and death, and the importance of the environment in healthcare settings). All healthcare professionals require knowledge from different areas, such as health, care and medical science, but each has an area of main focus. Nursing (Swedish: *omvårdnad*) is profession specific care actions that nurses are responsible for and have knowledge about (Arman, 2015). Radiography shares some of the features with nursing and medicine that are inherent in all caring roles, such as caring compassionately for the patient; however, some unique characteristics and specialization within medical imaging procedures separate radiography from other fields (Ahonen, 2008; Bleiker et al., 2016). Radiography involves caring, imaging and functional medicine, radiation physics, and medicine, meaning that research performed by radiographers be interdisciplinary (Andersson et al., 2017). Research by radiographers within radiology has been performed at least since 1988 (Hjelm-Karlsson, 1988), and radiography as a formal research field was established in 2001.

PATIENTS AND STAFF IN THE HYBRID OPERATING ROOM

RATIONALE

The environment we are in influences our accomplishments and sense of well-being. Nowadays, healthcare environments change rapidly toward more advanced techniques, which allow tremendous opportunities to care for and treat patients with critical diseases. Despite the scientifically strong evidence on how the hospital environment can impact both patients and staff, this perspective is rarely considered when hospitals renovate, rebuild or develop new facilities. Instead, the focus on the physical environment continues to be technically and medically oriented rather than on how the human factor may be impacted by it. In addition to learning and adapting to the rapidly changing technique and physical environment, healthcare staff are expected to work in teams that are often composed ad hoc, resulting in a great variety of meetings with different people.

The hybrid OR is an example of a highly technical environment where procedures demands collaboration between several medical specialties. During an EVAR in a hybrid OR, nursing and medical staff specialties such as anesthesiology, surgery, and radiology may be involved in the treatment of the patient. Collaboration with others can be challenging, especially in a new environment where roles and responsibilities are not clearly defined. This can create insecurity for the staff which could impact patient safety and the experience/perception of care. In addition to being a new physical environment for the patients and the staff, the hybrid OR also means a novel constellation of the team that demands collaboration between additional staff categories compared to a traditional OR. A well-functioning team is essential if good medical outcomes, high patient safety, and patient and staff satisfaction are to be achieved. Therefore, knowledge about the care and work process in the hybrid OR, together with the patient and staff experiences of such an environment, is important. This knowledge is vital to prepare the patients and staff in the best possible way and to create evidence-based guidelines and educational programs on best practice for working and caring in the hybrid OR.

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AIM

The overall aim of this thesis was to explore and describe the care and work processes, staff interactions, and experiences of both patients and staff in the hybrid OR.

SPECIFIC AIMS

The specific aims of the included studies were:

Study I

to illuminate the patients' lived experience of waiting for and undergoing an endovascular aortic repair (EVAR) in a hybrid operating room (OR).

Study II

to describe the work processes and collaboration in a hybrid OR during endovascular procedures where staff categories from anesthesia, surgery, and radiology were involved.

Study III

to evaluate team composition and staff roles in a hybrid OR during EVARs.

Study IV

to evaluate how the nursing staff from the specialties of anesthesiology, surgery, and radiology experienced working and collaborating in a hybrid OR.

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METHODOLOGICAL VIEWPOINT

The main ontological assumption in this thesis was that the nature of reality is subjective and multidimensional. Therefore, a qualitative methodological approach, which is a systematic, subjective approach used to describe life experiences and give them meaning, was chosen for most of the studies (Studies, I, II, and IV) that form this thesis. Qualitative methods are founded in human science tradition where process, content, interpretation, meaning or understanding people's experiences, perceptions, and lifeworld are of interest (Yilmaz, 2013).

In Study I, the intent was to describe and understand the phenomenon from the unique patients' narratives and hermeneutic phenomenology were, therefore, chosen in the analysis of the data. Hermeneutics, as a methodological approach, was used in Study II. The data was analyzed inductively, meaning that the data analysis was guided by the research objective while still allowing the research findings to emerge from the raw data without restraints imposed by structural methodologies (Polit & Beck, 2012). Since the aim of the thesis was also to describe and explain the context of the hybrid OR, a quantitative approach, was also used (Study III). Moreover, a qualitative orientation of content analysis, which has its origin in positivism, was used in Study IV. Beyond being descriptive, qualitative content analysis, according to Hsieh and Shannon (2005), can be used to interpret meaning from the content of text data, and thus, adheres to the naturalistic paradigm, that assumes that meaning is constructed by both participants and researchers. The naturalistic paradigm arose in contrast to positivistic traditions in which the scientific methods were considered the way to discover an objective reality.

PHENOMENOLOGY AND HERMENEUTICS

Phenomenology and hermeneutics were selected as suitable methodological approaches to Studies I and II because these approaches allow for the interpretation and analysis of textual information in order to enhance the meaning of day-to-day experiences of the participants. Phenomenology is an umbrella term that encompasses both a philosophical movement and a range of research approaches. The phenomenological movement was introduced by Edmund Husserl (1859-1938). Martin Heidegger (1889-1976), a disciple of Husserl, was one of the later theorists who reformed phenomenology from a strictly philosophical discipline that focused on consciousness and the essence of a phenomenon, to elaborating existential and interpretive (hermeneutic) dimensions (Kafle, 2011).

Hermeneutic phenomenology, which is derived from Heidegger's writings, focuses on the subjective experiences of individuals and groups. This approach attempts to unveil the world as experienced by the participants through their lifeworld stories. The approach's focus is toward revealing details within experiences that may normally be taken for granted or overlooked with a goal of creating meaning and achieving understanding of others' experiences (Kafle, 2011). This school of thought believes that interpretations are all we have, and describing experiences themselves is an interpretive process. The publications of Heidegger were later enriched by scholars like Hans Georg Gadamer (Gadamer, 1994), Paul Ricœur (Ricœur, 1976), and Max van Manen (van Manen, 1997).

The aim of hermeneutics, uncovering hidden meanings in texts through interpretation and understanding, can only be reached with an awareness of history and through pre-understanding. To generate the best possible interpretation of a phenomenon, hermeneutics proposes using the hermeneutic circle. For Gadamer (1900-2002), the task of hermeneutics was not to develop rules for what understanding is, but rather to serve as an instrument that we may use to clarify the basis of our understanding. Play is the hallmark of the event of understanding and playing means among other things that all participants accept certain rules that, cannot be changed by individual players. The concept of play in Gadamer's hermeneutic emphasizes that play only really

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exists when it is being played, and playing means that something is played and the player is subordinated to that play.

STUDY DESIGN

TABLE 1. Overview of included studies.

Study	Design	Data collection	Material/ participants	Data analysis
I	Exploratory qualitative design	Individual interviews	18 patients	Hermeneutic/ phenomenological approach
II	Exploratory qualitative design	Video recording	Nine video recorded EVARs	Hermeneutic approach, qualitative analysis
III	Descriptive quantitative design	Video recording		Descriptive statistics
IV	Exploratory qualitative design	Focus group interviews	Five groups of 17 staff total	Qualitative content analysis

The highlighted boxes indicate that the Studies II and III were based on the same data set.

STUDY SETTING

THE HYBRID OR

The setting for the studies that were included in this thesis was a prototype hybrid OR, which was built in May 2011. The room was rectangular and measured approximately 93 m². A small part of the room area was separate and served as a control room that was accessible only from an entrance in the corridor outside the hybrid OR. The entrance to the hybrid OR consisted of a sliding door, which could be held open in two positions (completely open and half open). To the right of the entrance, there was a small door hatch that could be opened by staff from outside the room to communicate or deliver material to staff inside the room with no need to open the entrance door. Near the door hatch inside the room, there was an area for the surgical staff and a desk with several monitors on it. The hybrid OR was divided into three different parts (see Figure 1) to serve the needs for staff from three different specialties: surgery, anesthesiology, and radiology. The room had different storage surfaces and both long-sides of the room were largely lined with cabinets with sliding glass doors. The storage cabinets on the right side, which could be seen from the entrance, contained material to serve the needs for the surgical staff. The corresponding storage cabinets on the opposite side contained material for the interventional radiological staff. Not far from the storage cabinets for radiology was an imaging processing area where a number of screens were positioned. The radiological exposure button was also available in this corner of the room (Figure 1).

The combined interventional-operating table/bed was height adjustable and located approximately in the center of the room. The patients were generally positioned with their feet toward the entrance. The area above the patients' heads contained the anesthesia equipment, including a desk area with computer monitors on it. The floor-mounted radiological equipment (fluoroscopy system, Siemens Artis Zeego) with pivotal arm was near the patients' heads and required approximately an equal amount of space as the combined interventional-OR table/bed in the parked position. Approximately 105

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additional medical devices and 25 monitors for multiple purposes, such as patient monitoring, image guidance, image processing and documentation, were available in the room. Some of the screens were large, ceiling mounted, and movable and were located on each side of the patient. Above the storage cabinets on each side of the room were large, fixed wall screens. Three booms for anesthesia marked A, B, and C were mounted to the ceiling: one in the anesthesia area and the remaining two near the entrance. One of the booms had a display that indicated the real-time radiation.

Different types of adjustable lighting were available, and there were two mounted surgical lights and a surgical camera above the OR bed. A number of wheeled devices were positioned on the floor throughout the room. Mobile radiation shields with wheels were available as well as a mounted ceiling shield near the OR bed. A wheeled contrast medium injector was located near the patients' feet. Two cameras that could record the procedures mainly for educational purposes were also installed in the hybrid OR.

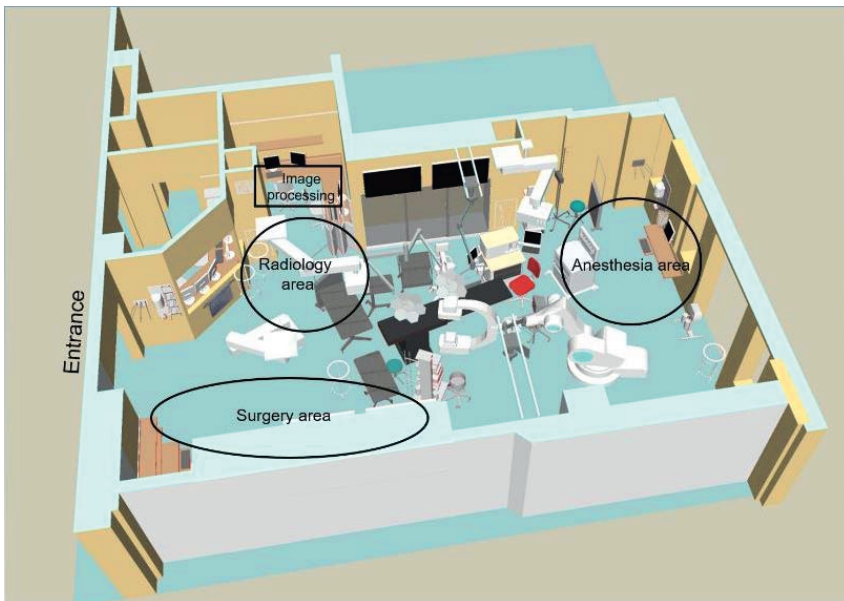


FIGURE 1. Illustration of the hybrid operating where the areas for different specialties (surgery, anesthesia and radiology) are marked. Source: Tyréns Arkitekter.

THE CAMERAS

The hybrid OR that was used for the studies in this thesis had cameras mainly for educational purposes installed in the ceiling of the room. The two cameras (BRC-z700, HD 3 CMOS) that recorded the entire room except for a small area that was called “image processing” were utilized to collect data for Studies II and III of this thesis. It was possible to adjust the cameras from outside the room by angling and zooming.

Before each of the nine video-recording sessions, the first author activated the cameras near the hybrid OR informing the staff in the hybrid OR that the procedure would be recorded. At the moment of camera activation, a sign was automatically activated inside the hybrid OR saying “Transmission in progress”. It was then possible to observe and record the procedure from a room outside the surgical department.

THE STAFF IN THE HYBRID OR

In a traditional OR, the team may differ, but within a Swedish context, it usually includes staff from the following categories: surgeon, anesthesiologist, nurse anesthetist, and OR nurse and assistant nurses from the specialties of surgery and anesthesiology. In interventional radiology, on the other hand, an EVAR procedure is usually performed by a team with interventional radiologists and radiographers.

Different staff categories worked in the hybrid OR during data collection. There were physicians from the different specialties of anesthesiology (anesthesiologists), vascular surgery (vascular surgeons), and interventional radiology (interventional radiologists). The vascular surgeons and the interventional radiologists performed the treatment on the patients together and are, in this thesis, collectively called operators. There were at least two operators involved in each procedure.

The nursing staff in this thesis refers to all RNs and assistant nurses regardless of specialty (surgery, anesthesiology, or radiology). The RNs in this thesis, therefore, include the OR nurses, nurse anesthetists, and radiographers. The assistant nurses had a specialization in either

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anesthesia or surgery and are here termed assistant nurse anesthetist and OR assistant nurse, respectively.

DATA COLLECTION

Data collection for this thesis included observations based on video recordings, individual interviews and focus group interviews. The period for data collection for the different studies is presented in Figure 2.

YEAR	2014		2015												2016							
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun		
Patient interviews Study I	█																					
Video recordings Studies II&III		█																				
Staff interviews Study IV																				█		

FIGURE 2. Period for the data collection in Studies I-IV.

RECRUITMENT AND SELECTION PROCESS

The recruitment for Studies I, II, and III were done simultaneously (see Figure 2). Studies II and III were based on the same video recorded material, and all patients included in the videos were also included in the interviews in Study I. An additional nine patients were included only in Study I. Figure 3 gives an overview of the inclusion/exclusion criteria. The inclusion criteria were that the treatment had to be: 1) an elective EVAR that was planned to be 2) performed in the hybrid OR with 3) staff from anesthesiology, surgery, and radiology. To be included, the treated patient also had to be 4) at least 18 years of age. The elective EVAR procedures took place only on Tuesdays and Thursdays, as the hybrid OR was utilized for other surgeries on the other days. Another consideration in the planning of the video recordings was that the room from where video recordings were captured was also used for other purposes. When the recording room was occupied, patients were asked only to participate in Study I. From November 2014 to September 2015, a total of 28 patients were asked to

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participate either in both Studies I, II, and III or only in Study I depending on the availability of the recording room on the day of their procedure.

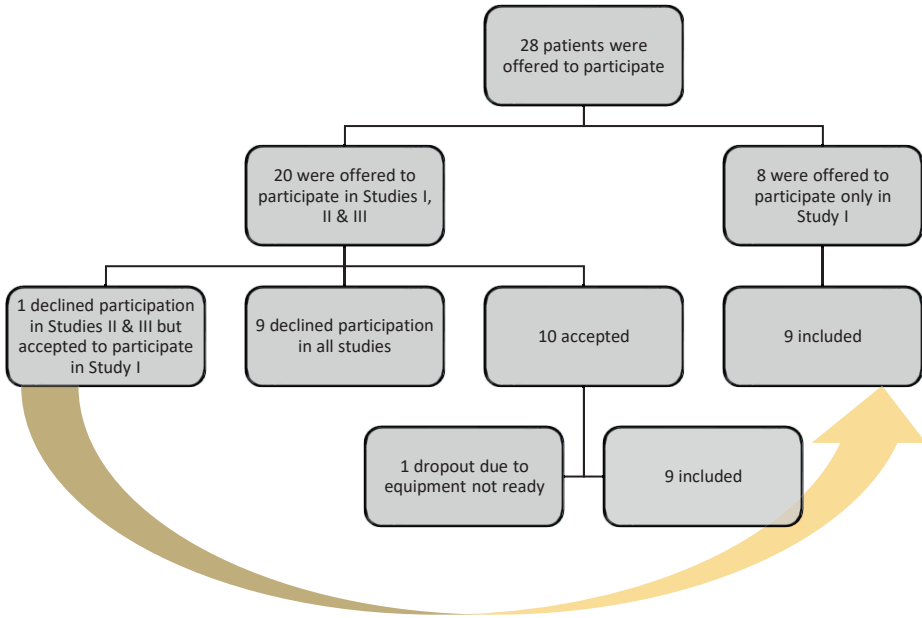


FIGURE 3. Procedure and participant selection for Studies I, II, and III.

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The recruitment for Study IV was conducted after data collection from Studies I, II, and III was completed. The intention was to recruit nursing staff from surgery, anesthesia, and radiology for focus group interviews with members of their own staff category (see Table 2). The nursing staff included five staff categories: nurse anesthetist, assistant nurse anesthetist, OR nurse, OR assistant nurse, and radiographer. At the time of the study, not all employed nursing staff was educated to work in the hybrid OR. Thus, to be eligible for inclusion in the study, the staff had to have worked independently in the hybrid OR on at least two occasions where staff from anesthesiology, surgery and radiology was needed. At the time of the study, 60 nurse anesthetists and 20 assistant nurse anesthetists were employed and all of them had been trained to work in the hybrid OR and, therefore, eligible to participate in the study. Fifteen out of 54 OR nurses and seven out of 33 OR assistant nurses were trained to work in the hybrid OR. All seven radiographers working within abdominal interventional radiology were also trained to work in the hybrid OR and eligible to participate in the study. The staff members were informed about the study and its purposes at several staff meetings, and all staff received an email with information about the study and an offer to participate. The manager of the unit announced the participation interest to the responsible researcher (MB) and the manager helped with arrangement of the time and place for the interviews.

TABLE 2. Overview of included participants in Study IV.

Group	Staff category	Eligible individuals (number)	Recruited	Dropouts	Included	Gender (F/M)	Work experience
1	Radiographer	7	6	0	6	5/1	3 mths-27 years
2	OR assistant nurse	7	3	1	2	2/0	1-30 years
3	OR nurse	15	4	1	3	3/0	9-35 years
4	Nurse anesthetist	60	4	1	3	2/1	5-25 years
5	Assistant nurse anesthetist	20	3	0	3	3/0	9-22 years
Total		109	20	3	17	15/2	

INDIVIDUAL INTERVIEWS

Study I used individual interviews with patients. Qualitative interviewing begins with the assumption that others' perspectives are meaningful, and researchers are interested in discovering their stories. Interviews involve verbal communication between the researcher and the participant by capturing a personal description of a lived experience, and the researcher aims to describe the phenomenon in as much detail as possible in the research findings (Patton, 2015). The intention of Study I was to capture the lived experiences of the patients through open-ended questions. The initial question was: Can you please tell me about what you experienced during the surgery? The interviews proceeded with follow up questions, such as: Can you tell me more about the operating room? Can you describe the environment of the operating room? How did you feel while being in the operating room?

All 18 patients included in Study I were hospitalized at the surgical ward the day before their EVAR treatments. After the treatment, all patients were transferred to the recovery room where they spent some time before later being taken back to the surgical ward. The researcher called the surgical ward the day after the treatment to ask if the patient had returned from the recovery room and to get a general status on the patient. The responsible nurse at the ward communicated with the patients concerning their ability and willingness to go through an interview and reported the patients' decisions to the researcher. In some cases the patients were not back at the ward within the expected time interval because of a complicated surgery, occurrence of complications, and/or a lengthier recovery time. In those cases the researcher had continuous contact with the nurse at the surgical ward to know when it was possible to interview the patient.

All 18 interviews were then planned and conducted, based on the patients' ability, 20-90 hours after the treatment procedure. The interviews took place in a separate room at the surgical ward and lasted for 16-97 minutes (see Table 3).

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TABLE 3. Overview of the interviews in Study I.

Interview number	Duration (hr:min:sec)	Treatment type	Gender	Time of interview (hr after treatment)
1	00:23:49	AE	M	68
2	00:16:46	AE	M	22
3	00:23:25	TE	M	24
4	01:36:50	AE	M	20
5	00:54:26	AE	M	24
6	00:41:45	AE	M	20
7	00:43:56	AE	M	24
8	01:08:28	AE	M	24
9	00:27:32	AE	M	24
10	01:12:55	AE	M	48
11	00:51:02	TE	M	24
12	00:19:39	AE	F	90
13	00:44:33	AE	M	72
14	00:20:42	AE	M	24
15	00:22:37	AE	M	24
16	00:40:30	AE	M	24
17	00:27:14	AE	M	89
18	00:34:13	AE	M	24
Median (Range)				24 (20-90)

AE = Abdominal EVAR, TE = Thoracic EVAR

VIDEO OBSERVATIONS

Video recording were used as a method for data collection in Studies II and III. Observation is an important method for collecting data about people, processes, and cultures, and observation has been used as a tool for collecting data for more than a hundred years (Einarsson & Hammar-Chiriac, 2009). Video observations help overcome limitations associated with observations without video and provide unprecedented opportunities because it allows multiple viewings with several observers. They reveal, for example how in surgical settings collaboration lies upon the ability of staff with differing responsibilities and skills (Heath et al., 2010). Within health and care science, video observations have been utilized in different settings and for different research objectives using hermeneutic approach (Eriksson et al., 2010; Karlsson et al., 2012; Karlsson et al., 2019; Nåden, 2010; Strand et al., 2017) but also with quantitative analysis within the OR context (Bayramzadeh et al., 2018; Bergström et al., 2018; Cumin et al., 2017).

After information was provided to both staff and patients and informed written consent was received from the patient, each of the nine video recordings started by activating the two cameras in the hybrid OR by pushing a button outside the room. The activation of the cameras did not mean that the recording had begun yet. Then the researcher (MB) moved to the room that was secluded from the surgical department and from where the procedures could be followed and recorded. Before leaving the surgical department, the available staff were informed not to wheel the patient in before the researcher had reached the secluded observation room. It took a few minutes to reach the observation room and the staff were phoned when the patient could be wheeled into the hybrid OR and the recording could start. The recording started the moment the patient was wheeled into the room and stopped when the patient was wheeled out of the room. The procedures were observed on two screens, and the cameras could be adjusted from the secluded room as required to cover the whole room. When the patient left the room, the video recordings ended, and the films were transferred to a hard drive that would later be kept locked in a secure filing cabinet. The length of each video is presented in Table 4.

TABLE 4. Overview of the video material in Studies II and III.

Video	Recorded time (hrs:min:sec)
1	05:24:20
2	04:46:36
3	05:16:09
4	04:52:27
5	06:27:17
6	07:31:48
7	04:47:29
8	04:52:14
9	04:40:41
TOTAL	48:39:00

FOCUS GROUP INTERVIEWS

Study IV was designed to capture the perceptions of the nursing staff working in the hybrid OR. Group interviews take a variety of forms and serve diverse purposes (Patton, 2015). Focus groups are a form of group interview that capitalizes on communication between research participants to generate data because our interactions with each other are how we come to more deeply understand our feelings and make sense of our behavior (Kitzinger, 1995). By bringing people together who share a similar academic or work background, for instance, researchers can create the opportunity for participants to engage in meaningful conversations about the topics under investigation (Patton, 2015). In Study IV, where the interest was a broader perspective from the nursing staff's point of view, focus group was chosen as a method for data collection. This was based on the fact that a focus group can stimulate a joint description and discussion among the interviewees, who could get ideas from others in the group, thereby providing richer material than could be obtained from individual interviews.

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Five focus group interviews were performed between May and June 2016. The time for the interviews was planned in consultation with the heads of the surgical and radiology departments together with the participants. All interviews, except the one with the radiographers, were conducted in a conference room that was secluded from the participants' department. The interview with the radiographers took place in a room in the radiology department due to difficulties of leaving the department in case of emergency.

An interview guide with questions composed by the research team and based on experiences from similar contexts and results from Studies II and III was created. The interviews started with the open question: Describe your thoughts on working in a hybrid OR followed by the predetermined questions in the interview guide that were constructed from five different concepts: *patient safety*, *caring responsibility*, *collaboration*, *roles*, *competence*. The main interview questions were as follows:

- Can you describe what *patient safety* in the hybrid OR means?
- How do you view the *caring responsibility* in the hybrid OR?
- What opportunities or obstacles exist for *collaboration* and communication in the hybrid OR?
- How do you view your own *role* as a member of the team in relation to other members of the team?
- What *competence* do you believe is needed to work in the hybrid OR?

The interviews were conducted by two researchers with different roles. One role (MB) was to ask questions and lead the discussions and the other role (KA/supervisor) was to act as a moderator by providing support, taking notes, and asking further questions when needed (Rabiee, 2004). The audio recorded focus group discussions lasted between 49-63 minutes (see Table 5) and were later transcribed verbatim by professional transcribers.

TABLE 5. Overview of the interviews in Study IV.

Interview	Staff category	Included number	Duration of interview (min)
1	Radiographer	6	55
2	OR assistant nurse	2	62
3	OR nurse	3	63
4	Nurse anesthetist	3	60
5	Assistant nurse anesthetist	3	49
Total (Mean)			289 (58)

DATA ANALYSIS

Analysis of the data had mainly a qualitative approach (Studies I, II, and, IV), but study III had a quantitative approach where statistical descriptive measure was validated and confirmed by field notes.

STUDY I - HERMENEUTIC PHENOMENOLOGICAL ANALYSIS

Each of the audio recorded interviews in Study I was played and listened to closely after they were completed to ensure technical quality. The interviews were later transcribed verbatim by MB. The analytic process, which were guided by openness to the phenomenon, began with reading through each of the interview’s texts from a holistic approach to become familiar with the data and understand the content. A discussion between MB and the supervisors took place, and a lifeworld analysis approach described by van Manen (1997) was chosen to analyze the content. Thematic analysis, according to van Manen (1997), is not a rule-bound process but a free act of “seeing”. In hermeneutic phenomenological tradition, thematizing meaning can be understood as related to the interpretation of data, illuminating the underlying or unspoken meanings embodied or hidden in lived

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experiences (Sundler et al., 2019). Phenomenological themes may be understood as the structures of experience, of meaning, of point, and they constitute the form of capturing the phenomenon one is trying to understand.

The thematic analysis was preceded by a detailed line-by-line approach where every sentence cluster of the texts in the patients' interviews were carefully read while asking the question about what it revealed about the phenomenon of waiting for and undergoing an EVAR in a hybrid OR. Collaborative discussions and reflections about the initial themes, which were reformulated during the process, took place between the co-authors. The final themes were reflected upon from the four lifeworld existentials: lived space (spatiality), lived body (corporeality), lived time (temporality), and lived human relation (relationality or communicability) (van Manen, 1997).

STUDY II - CROSS CASE ANALYSIS

The analysis approach in Study II was inspired by Gadamer's hermeneutics. The hermeneutic philosophy according to Gadamer (1900-2002) does not prescribe any special method for data collection and analysis, but it emphasizes that the achieved interpretation and understanding should be reasonable and about the topic, and that new or different understanding was received.

Through an inductive approach and based on Yin's (2014) description, a case study, favored for its use of "how" and "why" questions, was created in Study II. A case study is an empirical inquiry that investigates a contemporary phenomenon (the case) in depth within its real-world context, especially when the boundaries between the phenomenon and context may not be clearly evident. In Study II, the interest was to describe the work processes (the case) in interaction with its context (the hybrid OR) which was in line with Yins' (2013) thoughts of not isolating the real-world case from its contextual conditions pertinent to the case.

Case studies are, like experiments, generalizable to theoretical proportions but not to populations or universes. In this sense, the case study does not represent a "sample" and in doing case study research, the goal is to expand and generalize theories (analytic generalizations)

and not statistical generalizations. Despite the time requirements, the strength of Study II was that multiple-case design, where several cases were analyzed through their differences and similarities (cross-case analysis) and finally became one typical case, were used (Yin, 2014). The cross case analysis, that was performed in study II, resulted in a typical case or paradigm case similar to Patricia Benner's work (Benner, 1984) that advocates how specific clinical cases that stand out in one's memory can be used for educational purpose in nursing practice. A cross-case analysis was performed in Study II because of the interest in presenting a great variety in work processes and staff actions. Benner (1984) uses the term paradigm case. Such cases are easy to remember and, therefore, are important in education and when discussing and evaluating cases in nursing practice.

The nine videos in Study II were observed from two different camera views by MB and two supervisors/co-authors. The analysis started with the inductive approach where all three observers watched the videos and took initial notes independently. After a discussion, the three observers were in agreement that the EVAR procedures could be divided into four distinct phases (Figure 4). The phases were defined and recognized because of the different type of activities that occurred with clear breaking points. The four phases were then defined and described and called Acts according to Gadamer's (1997) thoughts of "play, acts, and actors". According to Gadamer, text creates a scene, which allow us to observe from the outside in the same way we watch a theater play. When we enter and absorb the games and play, we interpret them as real and become a part of the game.

In the next step of the analysis, the videos were again observed and additional notes in relation to the performed activities and involved staff were taken by the three observers. The involved staff were viewed as Actors and notes about the collaboration between the different Actors was also documented. Different cases were created for each of the videos, and in the final step of the analysis, the cases were compared by identifying their similarities and differences. The cross-case analysis, where characteristics of each Act could be amalgamated, were created. The typical case was reflected upon using Thylefors' (2014) team type index where main activities (tasks) were considered either multi, inter-, or transprofessional. An activity that was always performed by a

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specific staff category was named multiprofessional, an activity where several staff categories were involved and the roles were overlapping was called interprofessional and activities where all staff categories were involved was called transprofessional.

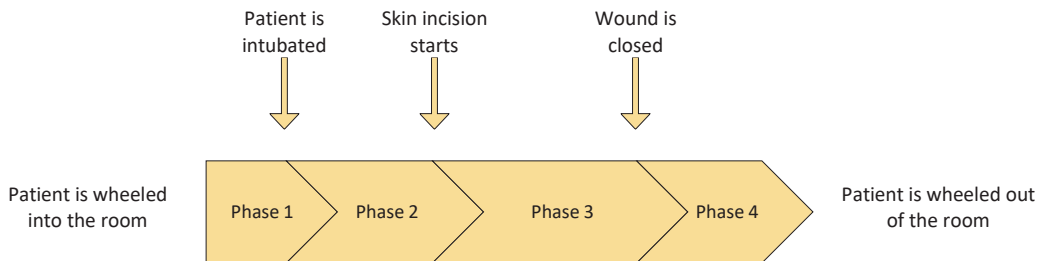


FIGURE 4. Definition of the four phases (Acts)

STUDY III - STATISTICAL MEASURES

Descriptive statistics were used in study III in order to describe the team composition in a hybrid OR during different parts of an EVAR. The median, mean, range (distribution), and interquartile range were calculated (Polit & Beck, 2012). Two observers performed the analysis and took notes separately using a previously created coding scheme (i.e., observation protocol). The analysis started by pausing the videos from the two camera views every ten minutes, which resulted in 293 observational moments, whereby the number of people visible on the screen and their title (staff category) were noted. In the cases where the observers could not assign the individuals to any of the staff categories usually in the hybrid OR, they were coded as “other.” After going through all the videos, the two observers compared their coding schemes (observation protocol) for consistency. When there was inter-observer disagreement, the observational moment was re-reviewed.

When working in their own area (the traditional OR room and the radiological intervention room, respectively), the OR nurses and the radiographers have similar roles when assisting the operators (vascular surgeon/interventional radiologist). To describe the work in the hybrid OR, a further review of the videos was done with a focus on the activity of the OR nurses and radiographers. An observation protocol aiming at

revealing the activity of the OR nurses and the radiographers was constructed. The activity time was defined as the duration of time the sterile gown was worn. The two observers watched the videos and noted independently when the OR nurses and radiographers put on and took off their sterile gowns. The observation protocols were then compared and in case of inconsistency between the two observers, an average time was calculated.

A further step in the analysis for Study III was by using a triangulation approach where the descriptive numerical data were cross-checked and confirmed by field notes made during the observations in Study II (Tobin & Begley, 2004).

STUDY IV - QUALITATIVE CONTENT ANALYSIS

Qualitative content analysis, which was used in Study IV, can be described as a set of techniques for a systematic analysis of texts of many kinds, addressing not only manifest content but also themes and core ideas found in the text (Mayring, 2014). Contextual information of latent (i.e., hidden) content and subjective interpretation through the systematic classification process of coding and identifying themes or patterns are included in this type of analysis (Hsieh & Shannon, 2005). Qualitative content analysis may be used to explore new topics, describe complex phenomena, compare and contrast group differences, and develop and test theories (Drisko & Maschi, 2015).

Coding in qualitative content analysis can be theory based and deductive, data grounded and inductive, or a mix of both approaches (Drisko & Maschi, 2015). Hsieh and Shannon (2005) distinguish between three approaches of qualitative content analysis: conventional, directed, and summative, depending on the research aim. All three approaches are used to interpret data from a predominantly naturalistic paradigm. Key differences among the three approaches center on how the initial codes are developed. Directed content analysis, which in contrast to the conventional approach uses predetermined codes, was used in study IV of this thesis. A systematic deductive approach was used because of an interest in performing the

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initial coding from some key concepts derived from earlier research in similar contexts and findings from Studies II and III of this thesis.

The analysis in Study IV was started by the researchers reading through all the transcribed interviews. A coding scheme based on the five concepts in the interview guide (*patient safety, caring responsibility, collaboration, role, and competence*) was created. During the analysis, some of the data could not be placed in any of the predefined categories and a new/further code, labelled *physical environment* emerged. Examples of how the interviews were analyzed are shown in Table 6.

TABLE 6. Examples of the analysis in Study IV.

Predetermined code	Quotation	Category
Patient safety	It has to be secured...it is higher safety when it comes to most things	Higher patient safety
Caring responsibility	The anesthesia have the main responsibility (for the patient) but when it comes to how the patient should lie on the table, we and the OR staff have the same responsibility.	Caring responsibility shared
Education	We have had training...but it feels like it is more directed towards the surgery and anesthesia staff.	Lack of education
Collaboration	...we could still collaborate a little better...help each other with patient positioning and preparation and sterility	Collaboration can improve

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ETHICAL CONSIDERATIONS

All four studies in this thesis were approved by the Ethical Review Board in Gothenburg (No. 392-14) and were performed in line with the Helsinki Declaration (Helsinki Declaration, 1964). Researcher ethics is about the researcher's ethical considerations of how a study is performed, one's role as a researcher, and the handling and publication of the information. In this thesis and all included studies, an ethical approach was strived for by making ethical reflections throughout the process, including the planning of the studies, collection of the data, and presentation of the results.

The four basic ethical principles of autonomy, beneficence, non-maleficence, and justice were considered in all studies of this thesis (Hermerén, 2011). The information that was given to the patients in Studies I, II and III included information concerning voluntariness, informed consent, and handling of their video recorded data. With regard to the patients' autonomy, all patients were also informed about their right to withdraw their participation at any time. All EVAR procedures were planned to be performed in exactly the same way regardless of participation in any of the studies. Therefore, the beneficence of the studies was judged to be higher than any potential harm.

There were several ethical aspects that were discussed at the planning stage of the studies. First of all, naturalistic observations with field notes were considered as an alternative to video observation because video material is sensitive, and thus recruitment could possibly prove difficult. After doing one test observation, it was concluded that due to the complexity of the hybrid OR and the number of people in it, it would be too challenging not to use the pre-existing cameras and record the procedures. Therefore, the choice to video record the procedures was reasonable; however, it raised the ethical dilemma of free informed consent for the staff on the videos. Since people unexpectedly went in and out of the hybrid OR, it was impossible to gain written informed consent from each. Therefore, consent was gained at a department level, and focusing on providing detailed information before each of the recordings. To ensure mal-efficiency, the

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information to the staff was essential. Oral information was given at several staff meetings, and staff were given the opportunity to ask questions. All staff received written information to their email, and objections to participate in the videos could be reported to their manager. An obvious sign stating when the recording was in progress was posted on the entrance door to the hybrid OR, along with written information about the study and its purpose. All these aspects together were considered to protect each individual as much as possible.

RESULTS

OVERALL RESULT

The findings in study I showed how the patients' experiences were largely related to the disease itself (aortic aneurysm). Waiting for surgery was both an anxious and hopeful period where the patients were afraid of their disease but had hopes of becoming better or cured after surgery. Communication with the staff and everyday talk with humoristic elements was appreciated by the patients.

The experience of a high amount of staff in the hybrid OR was mentioned by many of the patients in Study I, some of the staff in Study IV and was also noticeable in Studies II and III. This, together with the technical equipment, made the patients feel calm and safe. Also the results from Study IV showed that the nursing staff related the amount of specialist expertise and the technical possibilities of a hybrid OR to an increased patient safety. The extent of different safety preparations, which remarkably prolonged the procedures, was one of the results in Study II. Study III showed that the hybrid OR was most crowded in phase III when the wound was open. The nursing staff in Study IV explained their views on patient safety, from different perspectives, but none of the staff groups mentioned the amount of people or the number of door openings (a finding from Study II) as safety risks.

In Study I, the patients noticed how busy and stressed the staff seemed to be during the time they were awake (usually phase 1 of the procedure). The staff in Study IV were not asked about the effectivity of the procedures nor did they immediately talk about it. However, all staff groups mentioned how the division of labor between staff groups was uneven and the inactivity time for the OR nurse and OR assistant nurse was long. This was also a finding from Studies II and III where waiting times with the staff in standby positions was seen as strongly related to procedure effectivity. Without using the term of effectivity, the radiographers mentioned how they were always in a hurry and wanted to start up the procedures as soon as possible. They felt hindered from doing that because the OR nurses had different work

schedules (length of work sessions, staff rotation) and different terms of employment meaning they were not in the same rush.

The staff in study IV explained how much they enjoyed working in the hybrid OR and being a part of something new where ideas can be tested. When talking about collaboration, the staff in Study IV mostly indicated a well-functioning collaboration which was somewhat contradictory to the findings in Study II where collaboration was considered to happen in separate teams and partially fragmented. However, most of the staff explained that the success of collaboration was largely dependent on individual personalities.

The patients in Study I felt they were cared for and watched over but the distance to the staff was evident. The patients tried to not seek contact with the staff because they did not want to disturb them. The patient-staff interactions and communication was described differently by the patients (Study I) compared to the staff (Study IV). As the patients felt a distance to and did not wanted to disturb the staff by seeking contact, several of the staff categories described how they tried to keep a distance to the patient because they believed that the contact with too many people could have a negative impact on the patient.

The time after surgery was exhausting for the patients but they felt also relieved over that the surgery was over. The patients had several unexpected feelings after surgery and some did not expect that the surgery would be that exhausting.

STUDY I

Patients' lived experiences of waiting for and undergoing an endovascular aortic repair in a hybrid operating room: A qualitative study.

The interviews in Study I revealed that the lived experiences were related to the time before the surgery, the surgery itself, and the time after surgery. The following three main themes emerged:

Theme 1: Being scheduled for surgery implied both anxiety and hopefulness

Theme 2: Feeling watched over and surrendering to others in the technologically intense environment

Theme 3: Feeling relief but unexpected exhaustion after surgery

For the patients, the time before a scheduled surgery was a time of varied feelings that were sometimes opposing. The patients were grateful for getting a scheduled time for surgery but started to worry about the surgery itself and the risks associated with it. For some patients whose surgeries were postponed, they became even more anxious during the waiting period.

When it was time for the surgery, the patients were relieved that the time they had waited for had finally come. Surgery was, however, taken seriously by the patients, and they worried about what could happen during the surgical procedure. The environment of the hybrid OR was described as technical and the patients shared the experience of a crowded room. The hybrid OR did not, however, frighten the patients because the technical equipment and amount of staff contributed to a sense of being watched over and feeling safe.

After the surgery, the patients were relieved, this time was also related to unexpected exhaustion for many patients. Some of the patients encountered different types of complications. Even if information about the complications had been received by the patients before surgery, they did not expect this could happen to them.

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However, the patients were not remorseful about having gone through the surgery because living with an untreated life-threatening illness was also not a viable option.

STUDIES II & III

The drama in the hybrid OR: Video observations of work processes and staff collaboration during endovascular aortic repair

AND

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

Studies II and III were based on the same video material and their results will therefore be presented here as amalgamated. The typical case (paradigm case) in study II, also evident from the results of study III, showed how different type of activities took place in different Acts (phases) of the procedure. One main observable activity (task) in Act 1 was the patient transfer to the OR bed. The result of Study II showed how this activity engaged all staff in the room (in median five people according to Study III) and they helped each other to achieve the best possible patient transfer. Another main activity in Act 1 was the anesthetization moment where the main Actors (performers) were the nurse anesthetist and anesthesiologist.

Study II showed how Act 2 was extensive and involving a lot of safety preparation activities, with a mean number of seven people present in the hybrid OR during that phase of the procedure (Study III). The staff categories in the room could vary in different phases of the procedure but Study III revealed that at least an OR nurse, a nurse anesthetist and an OR assistant nurse were always present during the whole procedure. Act 2 was divided into three scenes. In Scene 1, the main activity was positioning the patient correctly on the OR bed, which was of interest for and involved all nursing staff. In Scene 2, different material and equipment was prepared for the interventional procedure. Two main Actors in this scene, the OR nurse and the radiographer, both got sterile dressed whereby they started to cover the patient and the equipment in sterile sheets. In Scene 3, all preparations were completed and the operators (usually one vascular surgeon and one interventional radiologist) entered the room, got sterile dressed,

and a time out procedure where all present staff introduced themselves, was conducted.

Act 3, which was the longest in duration, started with artery puncture (skin incision) which was performed by one of the operators. In Act 3, the activities were concentrated to a few of the staff and the main Actors were the operators and the radiographer who together performed the whole intervention. Though the activity in Act 3 was concentrated to a few of the staff, Study III showed that in this phase of the procedure, the highest number of people was present. At the end of Act 3, the OR nurse and radiographers usually switched places and the OR nurse then handled and dressed the wound/place of incision. Study III revealed how the OR nurse and the radiographer switched the role of being sterile dressed and being nearest the patient. In this aspect, the radiographer had a larger activity time compared to the OR nurse.

The operators and the radiographers usually left the room in the beginning of Act 4 of the procedure. The main activities in Act 4, was the patient awakening from anesthesia and different cleaning activities, which occurred in parallel. While the nurse anesthetist and the anesthesiologist awakened the patients, the OR nurse and OR assistant nurse were dedicated to cleaning and material sorting activities.

STUDY IV

Collaboration in the hybrid OR: A focus group study from the perspective of the nursing staff

The analysis in Study IV resulted in six different categories: 1) different safety perspectives; 2) responsibilities being shared and divided; 3) collaboration becoming better over time; 4) uneven division of labor and different terms of employment; 5) lack of education and joint meetings; and 6) environmental constraints.

All staff indicated that the patient safety was higher in the hybrid OR compared to both the traditional OR and radiological interventional suite. When talking about patient safety, the staff did so from different perspectives and in relation to their area of competence and expertise. All mentioned how they aimed to protect the patients, though in different ways. The sterile covering of the patients was largely discussed in the group of OR nurses, and they believed that this was their area of expertise. Having a just in case approach and dressing the patients as for an open surgery was considered a very important safety initiative. For the nurse anesthetist, monitoring the patients and ensuring that all the wires and catheters remained connected were a major patient safety task. The assistant nurse anesthetist explained how patient safety could be seen as reduced in the hybrid OR because the routines differed compared to those in a traditional OR, thereby increasing the risk of making a mistake.

The staff explained how their overall responsibility was shared and depended on the task/activity. They explained how the positioning of the patient was a shared responsibility, and they helped each other with that task. For the radiographers, radiation safety was their clear responsibility, but they explained how this was not always recognized by other staff categories. Some responsibilities were clear, especially for the nurse anesthetists who declared that neither a radiographer nor an OR nurse could do their job. Other responsibilities were not as clear. For example, the OR nurses were sometimes concerned and unsure whose responsibility it was to complete the material documentation.

All staff groups discussed how collaboration had started with uncertainty but stated that the collaboration had become better over time, and all of them have found their place on the team. They also talked about how enjoyable it was to work with different staff categories and to be a part of something new where they all worked together and solved problems as a team. Several of the staff groups talked about how collaboration could depend on the individuals and person chemistry of the team but flexibility was also seen as a personal characteristic that promoted collaboration.

The staff affirmed that the number of staff in the hybrid OR was usually high but also explained that all professional expertise was needed in order to perform the procedure safely. However, the OR nurses and OR assistant nurses could feel underutilized in large parts of the EVAR procedures, and they found this dissatisfying. Mainly the OR nurses and radiographers talked about their different terms of employment, which meant that the OR nurses had 24-hour shifts while the radiographers worked daytime and were on call for emergency services the rest of the day. This difference impacted their daily work and was, by both the OR nurses and the radiographers, considered to obstruct the work process in the hybrid OR.

All but the radiographer group, stated that there was a lack of joint meetings, both before and after a procedure, and those groups felt they needed more team gatherings. Even if some groups felt there had been significant training, they still mentioned the need for more education and training for the hybrid OR. The radiographers were the only staff category that believed the offered training was excessive and too focused on the surgery and anesthesiology staff and, therefore, did not benefit them.

The physical environment of the hybrid OR mainly concerned the nurse anesthetists and assistant nurse anesthetists. Environmental constraints obstructed communication and the nurse anesthetists believed that their location in the hybrid OR was too far from their colleagues (the assistant nurse anesthetists) outside the room.

DISCUSSION

METHODOLOGICAL CONSIDERATIONS

Based on the aim of the thesis, mainly qualitative (Studies I, II, and IV) but also quantitative (Study III) methods, which complement each other, were used. Qualitative methods were used to describe and explore in order to gain understanding and knowledge about the work and care environment of a hybrid OR. Quantitative methods were chosen to describe some important and main measures (e.g. number of people/nursing staff in the room, staff categories in the room) related to the thesis' overall aim in the context of a hybrid OR.

In qualitative research, there are no clear descriptions or approaches of how to achieve high quality. It is also difficult to define what is meant by high quality and the definitions can be diverse (Polit & Beck, 2012). Despite different ontological and epistemological foundations of qualitative content analysis and hermeneutic/hermeneutic phenomenology, rigor can be judged based on how the research is presented for the reader (Elo et al., 2014; Sundler et al., 2019). In this thesis, the intention was to present all parts of the research process, from data collection, to analysis and presentation of the results as thoroughly as possible in all studies (I-IV) to achieve credibility. Maintaining a reflective attitude, by making continuous reflections throughout the process, was sought in this thesis (Elo et al., 2014; Sundler et al., 2019). The reflections were made by questioning: Was the right method, sampling, interview questions chosen in relation to the study aim? Did the results answer study questions and was the data interpreted the right way? Did I understand it right? How was the whole process presented?

Studies I and II were further guided by openness and by questioning the pre-understanding, which means identifying and becoming aware of preconceptions that might influence the analysis. In interpretive phenomenology by van Manen (1997), the pre-understanding (prejudice) is what we already know or think we know about the phenomenon. My pre-understanding involved about 10 years' experience of practical work at the radiology department at the same

hospital where data for the studies were collected. However, the practical work did not include work in the context of a vascular interventional room or hybrid OR. My pre-understanding also included three years' experience as a teacher in the nurse radiographer program at the university. Of course the pre-understanding must have influenced both the initial and follow-up questions in the interviews and also the interpretation of the data (Studies I and IV) but in accordance with Gadamer (2004) the pre-understanding was considered as a necessity for understanding something differently.

Being several researchers with different backgrounds and experiences benefited the studies. In all studies (I-IV) several researchers were involved in the interpretation of the data giving their multiple views and questioning each other's statements. Additionally, in both study I and IV quotations from the original data were presented to demonstrate how the derived description were grounded in the data (Elo et al., 2014; Sundler et al., 2019). This is a way to allow the reader to determine whether the interpretations are reasonable or not.

Studies II and III which were based on video recordings were strengthened by the use of several observers (Heath et al., 2010). One main advantage of video recording is that it allows detailed and precise information, it allows multiple views and offers the opportunity to go back and check the data. In all types of observations, a discussion about the researcher effect should be made. In Studies II and III, the staff may have been affected in behavior because they knew about the researchers' presence and that the procedures were video recorded. However, this risk is judged to be minimal because the researcher was not physically in the room during the video recording. The staff had to concentrate on their tasks in the care of the patients and it is most unlikely that behavior would be changed for so long time as the procedures were.

There is varied information in the literature regarding the ideal number of people in a focus group. While one reference proposes between four to eight (Kitzinger, 1995), another suggests ten participant in a focus group interview (Rabiee, 2004). One of the groups in study IV had only two staff members and this can be questioned because usually the definition of a group is three or more people (Einarsson & Hammar-Chiriatic, 2009). It was, however, difficult to obtain larger

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groups despite several attempts. The material obtained in the group discussions was, however, considered as rich in content, and it gave a picture of the work in the hybrid OR from the perspective of both the well experienced and the less experienced staff.

The conscious choice of including only nursing staff, but not the physicians, in the interview study, does not mean that the physicians are seen as separated from the team. This choice was made to get a deeper understanding of the work and care situation for the nursing staff.

In study III, the activity time was only calculated for two staff categories, the OR nurse and the radiographer. Optimally, the activity time should have been calculated for other nursing staff, like the nurse anesthetist, the OR assistant nurse, and the additional radiographer who were not sterile dressed but present in the room. However, there were difficulties in finding a way to measure this and the main interest was anyhow to study the OR nurses' and radiographers' involvement in the procedure since these staff categories have similar roles when working in a traditional OR and a radiological intervention room. The definition of activity time for these was the time being sterile dressed. It may be questioned whether they were active only when being sterile dressed. This was, in fact, not the case because during Phase 2 of the procedure, both the radiographer and the OR nurse were busy preparing material and the equipment before they dressed sterile. This measurement was chosen to mainly show the activity in Phase 3 of the procedure which had the largest number of people present while only a few of them were directly involved in the procedure.

Some of the findings can be considered to be transferable to other and/or similar contexts where staff from different specialties are involved in the care of the patient. Both teamwork and technological innovation are essentials that become more and more common within healthcare and may face challenges similar to those of a hybrid OR. The patients' points of view were both related to the disease, the contact with the staff, and the experiences of the environment of the hybrid OR. However, the detailed description of the context for the study (the hybrid OR), allows the reader to assess the transferability of the results to other or similar study contexts (Lincoln & Guba, 1985).

REFLECTIONS ON THE FINDINGS

This thesis showed that the environment of the hybrid OR was experienced as a pleasant working setting by the staff and was considered to be safe from the perspective of both the staff and patients. Several challenges and potential improvements (improvement opportunities) were identified, however. Some of the challenges were related to the relationship with the patient, to the collaboration between staff categories, and to the procedure in general in the environment of a hybrid OR.

ESTABLISHING A CARING RELATIONSHIP

Many of the patients' experiences of the EVAR procedures were related to a feeling of unpredictability. Establishment of a caring relationship, where the patient can express their concerns and receive answers to their questions, has been shown to decrease the sense of unpredictability, relieve anxiety (Bergs et al., 2018; Gallagher et al., 2010), and increase patients' perception of safety (Bergs et al., 2018; Gallagher et al., 2010; Lundén et al., 2015). Apart from information about the procedure and other concerns, a good relationship with the staff could include small talk, which was also noted by the patients in this thesis and this is in line with other studies (de Ridder et al., 2018; Lundén et al., 2015). One question is if and how it is possible to establish a caring relationship in a hybrid OR environment. A caring relationship is also about building trust which is a challenge in a shorter stay facility, such as an OR (Thomas et al., 2019). In Study I of this thesis, the patients trusted both the staff and the technique. While several studies have highlighted the importance of the caring staff behavior for the patients' satisfaction in their perceived level of care, there is also evidence on how this kind of relationship is challenged by time pressure in a task-oriented, highly technological environment, such as the radiological intervention room (Lundén et al., 2012). Taking time to establish a relationship additionally positively impacts the patients' perceptions of caring (Thomas et al., 2019). Finding a balance between handling the technique and caring for the patient may prove difficult in certain

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settings, such as EVAR in a hybrid OR, that was investigated in this thesis.

Caring is about protecting and not harming the patient, which was apparent in Study II by the all safety preparations. Caring is also about being emotionally present and open to the patients' experiences (Watson, 1985). In this thesis, the patients indicated that they felt distanced from the staff with only superficial contacts with some of the staff that were involved in the procedure. This, according to the patients, was something they had to accept. The patients still reported feeling safe in the physical environment with the staff surrounding them, in part due to the highly technological atmosphere. All staff, including the nurse anesthetists themselves, explained that the caring responsibility and contact with the patient was mainly theirs. Continuity in the contact with the staff, which creates togetherness, is known to improve patient satisfaction (Hustoft et al., 2019; Pulkkinen et al., 2016). The nurse anesthetists, who met the patients before they entered the hybrid OR, indicated how busy they were with different tasks, especially in Phase 1 of the procedure, and that seemed to limit the available time they could subsequently spend building a caring relationship with the patients. That Phase should be where there was a focus on establishing caring relationships. This raises the question if another staff category, besides the nurse anesthetist, should take over responsibility for establishing the caring relationship, as other staff categories (e.g. the OR nurse and OR assistant nurse) indicated they were less utilized during large parts of the procedure.

The patients' sense of losing control and not having another choice was evident in the results of this thesis and in line with other studies (de Ridder et al., 2018; Douglas & Douglas, 2005; Marshall et al., 2012; Pulkkinen et al., 2016). This could be explained by the power imbalance that existed between the patient and the staff (Eriksson, 1996; Kasén, 2002; Lindwall, 2004; Marshall et al., 2012). Usually, when talking about the team in the OR, the patient was excluded. For patients to feel part of the team, it could be beneficial to include them, for example, in team briefing meetings. By including them in this way it could provide the patients a way to achieve some control of the situation (or the perception of control) and get familiar with the staff. All of these factors have been shown to create a sense of well-being and lead to more

positive outcomes (Arakelian et al., 2019). The patient could also correct the team on personal details and receive last-minute and sometimes the only specific information about their surgery during these briefings (Einav et al., 2010). However, not all patients may desire being a part of the team, but in general, the briefings could serve as an optional opportunity for those who do wish to participate in such way.

The results from Study I were beyond the initial aim of the study and covered the patients' experiences both before and after the EVAR procedures. The results showed deficiencies in relation to the information that was given to the patients about the procedure and the recovery time. In our, but also in Lundén et al.'s study (2015), the patients were surprised by all the preparations before surgery and how tired they were after the procedures in the recovery room, for example.

PROMOTING THE WORK IN THE HYBRID OR

The challenges related to teamwork within an OR environment are already recognized and can be claimed to be intensified in a hybrid OR according to the results of this thesis. Satisfactory teamwork not only impacts the procedure in general but helps create a positive atmosphere for both the patients and staff. A calm demeanor between the staff promotes a calmer patient (Stutzman et al., 2017).

WORKING AS A COHESIVE TEAM

The first challenge is to promote a team environment where all parties feel included and involved in the hybrid OR. The environment of a hybrid OR is more than a physical place, and the creation of positive, collaborative atmosphere, which should include a common vision, teamwork, and an attitude where each staff member's expertise is valued, could be developed by having staff engage in open dialogue, creating learning and participation (Salmela et al., 2017). However, the environment is also physical and, in this thesis, some shortcomings in the physical environment were associated with the initial design of the room, which was found to partly obstruct and/or limit teamwork.

DISCUSSION

The results from this thesis indicated how the staff from the specialties of surgery, anesthesiology, and radiology had a common goal (i.e., to perform the procedure in the best and most secure way), but they had different perspectives and priorities on how to achieve this. This was evident both from the results of Studies II, III, and IV, where the team in the hybrid OR consisted of several teams, so-called subteams, rather than one holistic team made up of several staff categories (Rydenfält, 2014). This may unfortunately promote a potential in-group/out-group mentality where staff may feel responsible for their own subteams' roles and tasks but do not feel responsible for or are unable to contribute to tasks that normally reside within other professional groups (Cumin et al., 2017).

Even if the staff in Study IV were asked to talk about collaboration in general terms, the focus for the nurse anesthetist, OR nurses, and assistant nurses was mainly directed to the collaboration in relation to the radiographers. This indicated that one difference between a traditional OR compared to a hybrid OR was the presence of the radiographers. In general, the staff in Study IV talked positively about their collaboration and perceived it as good. However, it was noticeable from Studies II and III that the actual collaboration they referred to was the one which mainly occurred in subteam. This resulted in waiting times, less effective procedures, and an uneven distribution of work. Due to the high demand of productivity and shortages of radiographers, nurse anesthetists and OR nurses in Sweden, it is important to discuss the distribution of tasks and how to utilize the competency of the staff in the most efficient way. The length of a surgical procedure has been shown to be independently affected by the size of the team (Cassera et al., 2009; Zheng et al., 2012). Limiting the team size to those who are directly involved is necessary also from infection prevention/reduction and patient integrity perspectives.

The different priorities in relation to one's subteam were considered to prolong the procedures in the hybrid OR according to the results of this thesis. An example of that was how the OR nurses focused on preparing and draping/covering the patient as for an open surgery even though they declared, in agreement with other data (Swedvasc, 2016), that the risk of conversion was minimal. No conversions from EVAR to open surgery have been done since the hybrid OR has been in operation

(personal communication). A thorough review of routine standard for EVAR procedures in a hybrid OR, where both patient safety and procedure efficiency are considered, is needed. Common guidelines about, for example, sterile techniques during EVAR procedures could be one specific area for consideration.

CREATING TRUST

The results from this thesis emphasize a need for all team members to see the procedure as a whole as well as seeing the patient as a whole. While the continuous presence in the room during the whole procedure would potentially facilitate the holistic perspective of the procedure, the presence of individual staff members varied between staff groups. It was, for instance, evident from Study IV that the OR nurses had problems with leaving the room during their time of inactivity because they were unsure about if the sterility was kept. This indicates a lack of trust to other professional group. In the establishment of a high performing team, trust must be built and that takes time (Ramaswamy et al., 2017). Competence trust is based on the confidence that the trustee has the acquired competence to handle a certain task. The strong competence trust, which was evident in a study by Rydenfält et al. (2012) where only anesthesia and surgical staff were included, was lacking in Study IV in relation to the radiographers' competence. The radiographers also explained how the other staff categories did not recognize that the radiation safety was one of their main competences and responsibilities. The question arises then if the lack of trust is based on ignorance about the radiographer profession or more on other factors. Better understanding of, and an openness to, each other's profession is needed. Job shadowing could be one way to promote that.

The drawbacks and instability of ad hoc or transient teams (i.e., unsettled teamwork), resulting in among other things, reduced patient safety and reduced staff satisfaction, is widely described in the literature (Bezemer et al., 2016; Gillespie et al., 2013; Williams et al., 2015). The OR nurses indicated how demanding and frustrating it was to work within so many different surgical procedures (also outside the hybrid OR) and keep their competence updated on each. This raises the

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question of the possibilities of building cohesive teams with the same staff constellations working together regularly. This would promote trust and open communication in the team (Rydenfalt et al., 2012).

OPENNESS IN THE TEAM COMMUNICATION

Communication breakdown, which may result in adverse events, is not rare within the OR environment (Lingard et al., 2004). Communication failures could to some degree be explained by differences in activity orientation between professions, which could in turn result in tension and inhibit information sharing (Rydenfalt et al., 2012). In this thesis, it became apparent how different staff members had different priorities and considered themselves to belong to a subteam. This is another factor that can cause communication failure. One way of reducing communication breakdowns, where the team members feel misinformed and only partly involved in the upcoming procedure, is formal team communication that promotes information sharing. This type of communication has been found to reduce the incidence of non-routine events and contributes to a safety culture (Cumin et al., 2017; Desender et al., 2017; Gillespie & Pearson, 2013). Different team briefings, both before and after the procedure, were also highlighted as important by the staff in Study IV of this thesis. Team briefings could facilitate seeing the procedure as a whole, but such briefings should be carefully planned and structured. This is because, according to the results of this thesis, not all staff were in the hybrid OR during the whole procedure. For example, the radiographer did not show up until Phase 2 or late in Phase 1 of the procedure.

A shared mental model is fundamental to effective team performance and depends on the effective communication of information between members of the team (Cumin et al., 2017; Floren et al., 2018). Multidimensional, shared mental models can simply be described as a cognitive construct of shared understanding among team members or as members being on the same page. (Floren et al., 2018). The shared mental model in relation to the task was measured in a study by Nakarada-Kordic et al. (2016). Deficiencies in sharing task mental models in relation to the work in a traditional OR has been

identified (Nakarada-Kordic et al., 2016). Agreement over who is responsible for what is important for team performance to ensure any task is not forgotten or wrongly assumed to be dealt with by others. Even though shared mental models were not evaluated in the studies of this thesis directly, there were some uncertainties in task responsibilities, which could be a result of the staff categories not having a shared mental model of the procedure. Two examples of this concerned the sterility responsibility and who was to complete the material documentation. The caring responsibility could also be judged as being unclear in some sense because the nurse anesthetists, who claimed this was their responsibility, also said that they were very busy with other tasks while the patient was awake and tried to balance the task performance and the communication with the patient. A question then is what the staff were really referring to when talking about caring since their discussions were mostly task-oriented and not related to the communication with the patient. Having shared mental models is a good way of describing teamwork but it does not usually include the caring responsibility for the patient. A concern then is that this responsibility tends to be forgotten in the context of a hybrid OR where several nursing staff categories are included and performing different functions. The extent of shared mental models, which includes the patient within the context of a hybrid OR, is an area for future research.

THE NEED OF LEADERSHIP

Strong leadership is necessary for any team to perform at optimal capacity (Ramaswamy et al., 2017). Leadership, which is associated with responsibility and considered to be crucial to effective teamwork, has been highlighted in the literature. Not only does the team leader coordinate the work and confirm that the members on the team are performing their tasks, he/she is also able to confirm each unique patient in suffering (Foss et al., 2018). Surprisingly, leadership was not visible in Studies II and III, and it was not mentioned by the staff in Study IV either. Leadership, which is usually distributed among several team members within traditional ORs (Rydenfalt et al., 2017), is described as essential to achieve goals through a successful functioning

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OR team. However, the operator, who is usually considered the team leader, should focus on the wider team with inclusion of all members (Parker et al., 2014). A discussion about appointing a team leader within the context of a hybrid OR could be valuable. This person does not necessarily have to be the operator or the same staff category for each procedure. Different staff categories can alternate taking the leadership role to avoid overburdening any one staff category. It should, however, be someone that is present in the hybrid OR during the whole procedure.

FULFILLING EDUCATIONAL NEEDS

The results of Study IV highlighted a dissatisfaction among the staff concerning not having their educational needs met in relation to working in the hybrid OR. Despite that, they indicated that there had been many education and training opportunities. A question this raises then is how the focus of the education can be structured and improved since the radiographers indicated that the education was directed more toward the OR and anesthesia staff to learn about radiology. Evaluation of the effect of education and training, and reconsidering the educational needs from the perspective of the whole teams' requirements should be paramount. A positive educational culture that stimulates learning, supported by the management, may be of fundamental importance for the staff's health and well-being (Ellström & Kock, 2008).

Although several of the participants in Study IV stated that team training through simulated scenarios was something they were involved in, it would be important to analyze if the training was based merely on the practical clinical scenarios that had less emphasis on the theoretical framework to optimize teamwork.

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CONCLUSION

In conclusion, this thesis indicated how the context of a hybrid OR had an impact on the work and care process as well as the experiences of both the patients and the staff. The challenges and improvement opportunities mainly revolve around the preparation of and communication with the patient, preparation of the staff, and the composition and performance of the team.

In general, the patients experienced the highly technological environment of the hybrid OR as crowded, safe, and calming. However, the patients expressed a feeling of unpredictability, which included worries about the disease, the surgery, and the recovery time after the procedure. Even if the patients did not express the distance to the staff in the hybrid OR as a major concern, it could have influenced their feelings of unpredictability. Continuous human contact and offering the patient the opportunity to be included in team briefing sessions could be ways of limiting the unpredictability that the patients felt in relation to the procedure. The feeling of unpredictability could also be alleviated by providing written and customized oral information to each patient's needs.

In general, the staff described the work environment of the hybrid OR as safe and enjoyable. The work and care process, however, largely took place in separate teams, which may not be optimal for patient safety, work satisfaction, or the effectiveness of the procedures. Active working time in relation to the procedure differed between the staff categories, and inactivity - waiting for the next phase of the procedure - was considered an area for improvements. The need of seeing the procedure as a whole by working as a cohesive team seemed evident. One suggestion in such complex environments as the hybrid OR could be to limit the work to a smaller, specially educated group of individuals. This expert group should, however, be small enough to promote collaboration but big enough to meet staffing requirements. Another way to promote teamwork could be by achieving better insight into and respect for each other's professions, which could be done by job shadowing, for example. It is also important that the physical environment is built to promote collaboration. Therefore, alternative

designs for where equipment and material are situated, for example the separate storage cabinets and documentation desks, should be considered.

The educational needs for working in a hybrid OR differed between the staff categories and were considered as unsatisfactory by some. Preparing the staff with education and training that targets the specific needs of each staff category would likely improve not only staff satisfaction but also maintain patient safety. Another request from the staff was the need for more formal interprofessional communication before and after each procedure. Also, work schedules (e.g. length of shifts, night versus day shifts) differed between staff groups, making coordinated and focused educational efforts difficult. After the data collection for this thesis were completed, an organizational change meaning that all nursing staff that would work in the hybrid OR environments became employed under the same organization. That together with the use of a common schedule system would probably facilitate the planning of education.

Based on the results of this thesis, alternative ways of creating the team, distributing the tasks, and adjusting safety preparations to each procedure could likely increase the effectiveness of the procedures in the hybrid OR.

CLINICAL IMPLICATIONS

The gained knowledge from this thesis could be utilized and implemented clinically in several ways. Based on the perspective of the patient, the communication and information that is delivered to them should be reconsidered. Both standardized written information and customized information about the procedure are needed and should be developed. The information that is given to the patient should be realistic to prevent the patients from imagining the EVAR procedures as an easy treatment compared to the alternative treatment of an open repair. The distance between the patient and the staff found in the context of the hybrid OR could be addressed by appointing a specific staff member to have the main responsibility for the communication, thereby providing a contact person for the patients and meeting their needs.

The simulated scenarios, which are already used as part of the team training methods, should be formed, tested, evaluated, and updated in alternative ways by using the results from this thesis. For example, another composition of the team and distribution of the tasks between the team members could be simulated and tested. It is, however, important that the staff's educational and training needs for working in the context of a hybrid OR are completed before the simulated scenarios are implemented in a real care context.

The results from this thesis could also be a base for internal (e.g., within departments) improvement projects regarding exposing patients to infections unnecessarily in any OR. Challenges related to the culture of door openings, presence of unnecessary people in the ORs, and lunch reliefs/breaks during surgical procedures should all be investigated to enhance patient safety further.

Furthermore, the results could provide guidance and support in academic discussions about developing more specialized training for the hybrid OR environment in the current academic curriculum.

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FUTURE RESEARCH

Because the context of a hybrid OR is scarcely investigated from a collaboration perspective or from the experiences of both patients and staff, there are several suggestions for further research based on the results of this thesis.

The new hybrid ORs in BoIC have already been in use for several years, and it would be interesting to explore these with a naturalistic approach and compare those results to those of this thesis.

Future research could also investigate and look deeper into how communication takes place between the staff and the patients in the context of a hybrid OR during procedures other than EVARs. This would also provide the opportunity to understand the conscious patients' perspectives on their care because not all procedures in the hybrid OR use general anesthesia.

Another area of future investigation is how the information about the treatment is given to the patients and in what way it may affect the patients' feelings of satisfaction toward the care they received. If and how the information is given about a newly-built hospital environment may have an impact on the patients' sense of well-being. It would also be vital to determine whether or not the level of patient satisfaction is related to how and who gives them the information. This would then allow carers and hospitals to determine the precise type of individualized information and how it should be delivered to increase patient satisfaction.

More knowledge about the composition of the hybrid OR team is needed. Evaluation of the competencies needed for working in a hybrid OR should start from the team as whole, beyond that of each staff category's professional development.

Understanding the leadership in the hybrid OR is a topic that needs further evaluation. How leadership at an organizational level can encourage teamwork and collaboration should also be an area for investigation.

The safety culture in the hybrid OR, which assesses, for example, the traffic flow and the presence of unnecessary staff in the room should also be addressed.

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Even if efficiency and patient safety are already of central importance within the hybrid OR, these are also influenced by trust between members on the team. Therefore, research about how trust can be built/created in the hybrid OR is needed.

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