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Mapping registered nurse anaesthetists' intraoperative work: tasks, multitasking, interruptions and their causes, and interactions: a prospective observational study

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ABSTRACT

Introduction Safe anaesthesia care is a fundamental part of healthcare. In a previous study, registered nurse anaesthetists (RNAs) had the highest task frequency, with the largest amount of multitasking and interruptions among all professionals working in a surgical team. There is a lack of knowledge on how these factors are distributed during the intraoperative anaesthesia care process, and what implications they might have on safety and quality of care.

Objective To map the RNAs' work as done in practice, including tasks, multitasking, interruptions and their causes, and interactions, during all phases of the intraoperative anaesthesia work process.

Methods Structured observations of RNAs (n=8) conducted during 30 procedures lasting a total of 73 hours in an operating department at a county hospital in Sweden, using the Work Observation Method By Activity Timing tool.

Results High task intensity and multitasking were revealed during preparation for anaesthesia induction (79 tasks/hour, 61.9% of task time spent multitasking), anaesthesia induction (98 tasks/hour, 50.7%) and preparation for anaesthesia maintenance (86 tasks/hour, 80.2%). Frequent interruptions took place during preoperative preparation (4.7 /hour), anaesthesia induction (6.2 /hour) and preparation for anaesthesia maintenance (4.3 /hour). The interruptions were most often related to medication care (n=54, 19.8%), equipment issues (n=40, 14.7%) or the procedure itself (n=39, 14.3%). RNAs' work was conducted mostly independently (58.4%), but RNAs interacted with multiple professionals in and outside the operating room during anaesthesia.

Conclusion The tasks, multitasking, interruptions and their causes, and interactions during different phases illustrated the RNAs' work as done, as part of a complex adaptive system. Management of safety in the most intense phases—preparing for anaesthesia induction, induction and preparing for anaesthesia maintenance—should be investigated further. The complexity and adaptivity of the nature of RNAs' work should be taken into consideration in future management, development, research and education.

Strengths and limitations of this study

- This study adds to the limited knowledge on registered nurse anaesthetists (RNAs') intraoperative work, including tasks, multitasking, interruptions and their causes, and interactions, illuminating the changing intensity across different phases of intraoperative anaesthesia care.
- The data collection tool used, Work Observation Method By Activity Timing, employs a structured observation protocol with an operationalised definition of 'interruption', which may reduce the risk of potential measurement errors.
- Some participants were observed on several occasions, which may imply a risk of systematic bias.
- This study was performed at one hospital only, the observations did not include night shifts, weekend shifts or procedures conducted on Fridays, and the number of observed RNAs was relatively small, which may limit the representativeness and reduce the generalisability of the findings.
- It should be acknowledged that as the phases were constructed after the original data collection, some tasks, with long duration may extend across two or more phases, such as supervision, making the frequencies and proportion of times an estimate.

INTRODUCTION

Safe anaesthesia care is a fundamental, indivisible and indispensable part of healthcare delivery.[1] The anaesthesia care has evolved into a highly technical and cognitively demanding care process, conducted in the rapidly changing, complex adaptive system (CAS) of an operating room (OR).[2–4] The intraoperative anaesthesia work process consists of several phases: preoperative preparation, intraoperative care, induction of anaesthesia, maintenance of anaesthesia, emergence from anaesthesia, preparation for the postoperative period and extubation.[5 6]

The WHO's surgical safety checklist, including sign in, time out and sign out, should be taken into account during work.[7] Phases and tasks have been mapped in flow charts[8] and described generally, with a focus on ergonomics and human factors,[2 6 9–12] efficiency of the processes[13 14] and on how safety emerges using systemic approach.[15 16] According to resilience engineering, healthcare and resilience can be defined as the ability of the CAS to rapidly respond and adapt to both expected and unexpected conditions.[17] A way to learn from such adaptations may be through identifying differences between work as planned by those who write the procedures and work as done in practice.[17] This has led to a focus on understanding and describing everyday clinical work processes and tasks.[18] The aim of this study is to broaden this understanding through elucidating registered nurse anaesthetists (RNA's) work as done.

Multitasking—managing multiple tasks simultaneously[19]—is one adaptation that has been studied in acute care at emergency departments,[20–24] intensive care units[25] and in ORs, from the perspectives of surgeons[26] and surgical teams.[27] Multitasking is often used as a strategy to cope with increased work and task density,[23] and has been described as an integral and appropriate part of acute care.[22 23] Multitasking has also been identified as a factor related to errors and adverse events, especially when there is a high cognitive load.[23 24] However, in order to be able to prevent errors, it is important to map the prevalence of multitasking and the situations when it occurs during RNAs' intraoperative work.

Serious adverse events are relatively rare in anaesthesia, but may cause considerable harm or even death.[28] However, interruptions and disturbances are present in every operation.[29 30] As a phenomenon, interruptions, disruptions and distractions have been challenging to encapsulate, resulting in multiple overlapping definitions. Interruption has been defined as 'discontinuity in task performance, an intrusion of a secondary, unplanned task and externally or internally initiated'.[31] Interruptions have an inherent potential to cause harm if they affect the progress of safe care by causing lapses in attention, delays of tasks, or unnecessary multitasking.[32] It has been acknowledged that interruptions may also be a strategy for a team to handle complexity and ensure patient safety, for example, when raising concerns about a possible risk.[27 32 33] Although adaptive responses to interruptions and multitasking in interaction with the surgical team may be key to safety performance in anaesthesia care,[27] interruptions and distractions remain a safety risk and need to be investigated further.[31]

In the OR context, interruptions have been investigated from the perspectives of the surgical team[27 34] and of the surgeon.[35 36] In anaesthesia care, interruptions have been investigated focusing on anaesthesiologists' work during procedures,[37 38] during specific phases of the anaesthesia process, such as during preoperative care[29] or induction,[32 39 40] or in simulated environment.[41] In anaesthesiologists' work certain moments of the anaesthesia process involving task complexity and workload, such as emergence for anaesthesia, were identified as more prone to being affected.[11 41] Self-initiated, non-clinical distractions such as reading or listening to the radio were found to be common among anaesthesiologists and RNAs, without impairing vigilance or causing adverse events.[42] In addition, external staff, opening doors, handling telephones and equipment-related and procedure-related issues may cause intraoperative interruptions.[27 34] Thus, in order to plan effective interventions for management of interruptions, the risk-prone moments in the real work processes of the RNAs should be explored.

The professional roles of RNAs' vary between countries,[43] making direct comparison of studies on intraoperative anaesthesia care challenging. RNAs' work has been studied as regards to non-technical skills,[44 45] experiences from clinical work processes,[46 47] skills assessment using simulation,[48] experiences of the WHO's surgical safety checklist,[49] patient advocacy[50 51] and work experiences.[52] Among the professionals working in the surgical team, RNAs had the highest task frequency, with the largest amount of multitasking and interruptions.[27] However, there is a lack of knowledge on how these factors are distributed during the intraoperative anaesthesia care process, and what implications they might have for safety and quality of care. To conclude, RNAs' intraoperative anaesthesia work process has not yet been described, which makes elaboration of potentially risk-prone moments and their management in practice challenging. The aim of this study was to map the RNAs' work in practice, including tasks, multitasking, interruptions and their causes, and interactions during all phases of the intraoperative anaesthesia work process.

METHODS

Study design and setting

This prospective observational study mapped RNAs' intraoperative anaesthesia work process. This study was part of a structured direct observational time and motion study of operating teams (surgeons, OR nurses and RNAs), which was conducted in an OR department at a local county hospital in Sweden.[27] The hospital had three surgical inpatient wards (62 beds in total), performing about 4100 surgeries annually. The central OR department had six rooms that served both acute and elective orthopaedic and surgical patients. Each operation room had a separate preparation room, with anaesthesia equipment, medication and equipment for monitoring the patient.

Sample

The unit of observation in this study was the RNAs' intraoperative work process. The rest of the surgical team was captured indirectly through documentation of tasks, including interactions with other team members or external professionals. No patients were observed. Observed procedures were selected from the case list in

the OR department, based on a convenience sample. The observation sessions were selected to achieve coverage across weekdays (Monday–Thursday) and times (07:30–21:00 hours). To capture variation, different surgical procedures were chosen and both acute and elective surgical procedures performed in adults were included. Observations were not conducted in ORs with orthopaedic procedures, due to infection control regulations in the hospital.[43]

In Sweden, RNAs are qualified nurses with a graduate diploma in specialist nursing, who independently induce, maintain and end general anaesthesia, including extubation, with support from anaesthesiologists, who are ultimately medically responsible. The anaesthesiologist's role depends on the patient's classification, as described by the American Society of Anesthesiologists, and the acuteness of the procedure.[53] The role of an RNA is to safeguard the intraoperative care process for the patient. In total, 16 RNAs were eligible for participation, with eight being observed. On mean, the observed RNAs had 18 years' experience as specialists (range 3–28) and 14 years' experience as RNAs at the study hospital (5–34). Their mean age was 50 years (32–64). Three were women and five men.

The relatively small number of RNAs included was due to practicalities regarding possible observable procedures and the RNAs' working schedules, with all RNAs being observed more than once, between 2 and 6 times. Written informed consent was obtained from all observed RNAs prior to the procedures. In addition, patients were informed about the observations and were given the opportunity to opt out. However, all gave their verbal consent. The study was conducted in accordance with the Helsinki declaration of research ethics.[54]

Instrument

Observational data of the RNAs' work process was recorded on a portable touchscreen tablet (Lenovo 7 Tab3) running the Work Observation Method By Activity Timing (WOMBAT) software.[55] The software takes into account multiple dimensions of work, as well as specific task categories and subcategories within these dimensions. Task categories were adapted to fit the RNAs' work tasks as described in a previous exploratory study (online supplemental appendix 1).[27] Each task classification included information about the task activity undertaken (What), with whom (Who) the participant interacted (eg, other members of the surgical team), resources (How) used (eg, telephone) and the causes (Why) of any interruptions or multitasking that occurred. Multitasking and interruptions have been given different definitions,[19 56] and in this study interruptions were defined as stopping a current task to respond to an external stimulus such as a pager, and multitasking was defined as performing two tasks simultaneously. Both were recorded in WOMBAT. Tasks performed by the RNAs and causes of interruptions (Why) were recorded based on the predefined categories (online supplemental appendix 2). Training and pilot-testing were performed prior to actual observations.

Inter-rater reliability was calculated in accordance with the WOMBAT manual using a comparison between the observers' recordings as regards frequency of tasks. In total, 12 rounds of inter-rater reliability testing were conducted by the researchers, independently observing the same participants for 30 min.[27] Inter-rater reliability was calculated by comparing the numbers and types of tasks recorded by the two researchers. Cohen's kappa was calculated from the last three pilot observations. The most frequently observed tasks were 0.85 for indirect care (pre and intra), 0.87 for direct care, 0.93 for medication and 0.82 for communication. According to the WOMBAT manual, once an inter-rater reliability ≥0.81 has been achieved, data collection may commence. The total Cohen's kappa score for frequency of tasks was 0.86, which was regarded as a high observer agreement.[57]

Data collection

Two researchers (CG and KO) performed the observations of the surgical teams, between 07:30 and 21:00 hours on weekdays from 14 November 2016 to 15 December 2016, resulting in a database of 11 791 tasks. In an earlier publication, we have presented the overall findings at a team level, covering 26 observed procedures per profession.[27] However, RNAs were observed during 30 procedures, which is the sample used in this study. The observations started when an RNA began the planning and preparation for a patient's anaesthesia in the OR and stopped when the patient was transported from the OR to the recovery room. Each participating RNA was shadowed unobtrusively. None of the observations exceeded 4 hours in length, because the researchers' ability to concentrate and the quality of observations might have been affected by longer observation periods.

Data analysis

All data containing observations of RNAs' tasks, multitasking, interruptions and their causes, and interactions were separated from the original database by the first observer (KO), resulting in a dataset with 5291 tasks in total. In order to describe the work done by RNAs in the intraoperative anaesthesia work process in greater detail, the observational data with RNAs' tasks were grouped based on the previously identified phases of anaesthesia care,[5–7] using the start time of tasks in each phase. In addition, recurring work patterns were identified, such as preparation for induction and maintenance of anaesthesia. These were included in the intraoperative anaesthesia work process (online supplemental appendix 3), which was then used as a framework for sorting the data regarding tasks, multitasking, interruptions and interactions with other professionals in or outside the OR. The second observer (CG) confirmed the sorting of the data and phase-specific outcomes.

Quantitative analysis of data was performed using Microsoft Excel (2016) and the Statistical Package for

Social Sciences (IBM SPSS Statistics; V.21). To analyse work patterns in the anaesthesia process, descriptive statistics were used, including total observation time, number of tasks, task frequency, total task time (hours), category-specific task time, proportion of category-specific task time, category-specific multitasking time, proportion of task time spent multitasking, interruption rate per hour and number of causes of interruptions.

RESULTS

Demographics

In total, 30 procedures were observed, extending across 73 hours, starting when a RNA entered the OR and began to plan and prepare for the anaesthesia, and lasting until the patient was transported from the OR to a recovery area. Time from incision until end of surgical procedure ranged between 38 min and 3 hours and 15 min. Out of the 30 procedures, two were acute and 28 elective, with 29 performed under general anaesthesia and one under spinal anaesthesia. In 12 procedures, a nursing student was being supervised.

Observed tasks, multitasking, interruptions and cooperation partners per phase

A total of 5291 tasks (72.5 tasks/hour) were identified in the RNAs' intraoperative anaesthesia work process. Communication was the most frequently observed task (n=1264, 23.9%, out of which conducting phone calls n=160) with intraindirect care as the second (n=1188, 22.5%) (table 1). A detailed description of task and subcategories can be seen in online supplemental appendix 1.

During the intraoperative anaesthesia work process, RNAs spent 62.3% of their time multitasking. The proportion of time spent multitasking was highest during preparation for anaesthesia maintenance (80.2%) and before initiation of surgery. During preparation for anaesthesia induction and in maintenance of anaesthesia, the RNAs multitasked more than half of the time (61.9% and 63.5%, respectively). The only phase in which multitasking was not highly prevalent was preoperative preparation (table 2).

However, looking at category-specific task time, the highest proportion of time was spent on intraindirect care (52 hours 55 min, 41.9%), followed by supervision (23 hours 11 min, 18.4%) and direct care (12 hours 16 min, 11.7%). The distribution of tasks varied between phases, reflecting the changing demands in the intraoperative anaesthesia work process (figure 1). RNAs spent a lot of time on supervision at the beginning of the procedures, such as during preoperative preparation and during preparation for anaesthesia induction. Direct care was apparent during preparation, induction and extubation. The rest of the anaesthesia time was indirect care.

Interruptions occurred most frequently during anaesthesia induction (6.2/hour), during preoperative preparation (4.7/hour) and during preparation for anaesthesia maintenance (4.3 /hour) (figure 2). In all, 272 interruptions were identified (3.7/hour). The interruptions in RNAs' work most often involved medication care (n=54, 19.8%), equipment-related issues (n=40, 14.7%), such as missing or malfunctioning equipment, or were procedure-related (n=39, 14.3%), such as the surgeon asking for a rapid change of patient's position. RNAs reacted to interruptions primarily by professional communication (n=51, 23.1%) and by medication care-related activities (n=41, 18.6%), such as administering medication.

Most of the RNAs' time in the OR was spent on independent work (76 hours 20 min, 58.4%) (figure 3). Time was also spent in interaction with a student (19 hours 51 min, 15.2%) or directly with the patient (19 hours 05 min, 14.6%), the circulating nurse (3 hours 48 min, 2.9%) or the anaesthesiologist (2 hours 46 min, 2.1%). Most interactions took place during preparation for anaesthesia induction, induction, preparation for extubation or extubation.

DISCUSSION

This study contributes with new insights into how RNAs' tasks, multitasking, interruptions and their causes, and interactions are distributed during the intraoperative anaesthesia work process. In Sweden RNAs' role is relatively independent, and their responsibilities cover most of the intraoperative anaesthesia care process, making them a key contributor to intraoperative safety.[53] Based on the observations, the task frequency (72.5 /hour), proportion of multitasking (62.3%) and interruptions (n=272, 3.7 /hour) cumulated often simultaneously in certain phases, such as during anaesthesia induction, preparation for anaesthesia maintenance and extubation. RNAs conducted most of their intraoperative anaesthesia work independently (58.4%), but when interacting, it involved multiple professionals, also outside the OR. When combining these different aspects of practice, a picture of a complex and dynamic work process is revealed. Previous research regarding RNAs' work has focused on areas such as non-technical skills,[44 45] experiences from different clinical aspects of work,[46–49] patient advocacy[50 51] and work experiences.[52] This study builds on this knowledge by illuminating how RNAs' work is actually done, uniquely mapping the different dimensions of work in relation to the intraoperative work process and thus providing further insights into the context and challenges for safe practice. As the core of anaesthesia care and the safety-critical moments are the same regardless of context, this study presents possibilities for both training—timing the use of non-technical skills to safety-critical moments—and for design of safer work practices in relation to the different intraoperative phases. Below, the findings are presented linked to the phases of the anaesthesia work process.

Preparation

During preoperative preparation, that is, when starting the work process in the OR, multitasking was not prevalent.

Table 1 Numbers of task categories, subcategories and proportions of subcategories per phase in 30 procedures in RNAs' intraoperative work process

Process phase, n (%) task categories Subcategories, n (%)	Preoperative preparation	Meeting with the patient	Preparation for anaesthesia induction	Anaesthesia induction	Preparation for anaesthesia maintenance	Maintenance of anaesthesia	Preparation for extubation	Extubation and transfer	WHO sign in	WHO time out	WHO sign out	Total n (%)
Communication												
Professional	41 (71.9)	3	7 (14.5)	13 (11.6)	46 (20.2)	163 (26.6)	26 (32.5)	15 (28.3)	20 (100)	26 (100)	22 (100)	
Case irrelevant	16 (28.1)	2	41 (85.4)	99 (88.4)	182 (79.8)	450 (73.4)	54 (67.5)	38 (71.7)	0	0	0	
Total	57	5	48	112	228	613	80	53	20	26	22	1264 (23.9)
Intraindirect care												
Disinfect	0	0	6 (4.7)	1 (0.9)	20 (8.2)	29 (5.5)	2 (1.8)	0	0	0	0	
Organise/arrange	0	1	89 (69.0)	55 (50.9)	88 (36.2)	106 (20.0)	46 (40.7)	35 (56.5)	0	0	0	
Control	0	0	1 (0.8)	1 (0.9)	5 (2.1)	4 (0.8)	0	0	0	0	0	
Read	0	0	8 (6.2)	10 (9.3)	35 (14.4)	158 (29.8)	10 (8.8)	3 (4.8)	0	0	0	
Observe/monitor	0	0	6 (4.7)	18 (16.7)	53 (21.8)	144 (27.1)	11 (9.7)	1 (1.6)	0	0	0	
Protect	0	1	14 (10.9)	14 (13.0)	11 (4.5)	44 (8.3)	20 (17.7)	2 (3.2)	0	0	0	
Clean	0	0	5 (3.9)	9 (8.3)	31 (12.8)	46 (8.7)	24 (21.2)	21 (33.9)	0	0	0	
Total	0	2	129	108	243	531	113	62	0	0	0	1188 (22.5)
Medication												
Administer	0	0	12 (15.0)	78 (57.8)	67 (40.6)	240 (51.5)	34 (41.0)	9 (33.3)	0	0	0	
Discuss	12 (17.9)	1	46 (57.5)	27 (20.0)	38 (23.0)	87 (18.7)	12 (14.5)	2 (7.4)	0	1	0	
Document	8 (11.9)	0	1 (1.3)	0	3 (1.8)	10 (2.1)	2 (2.4)	1 (3.7)	0	0	0	
Prepare	47 (70.1)	1	21 (26.3)	30 (22.2)	57 (34.5)	129 (27.7)	35 (42.2)	15 (55.6)	0	0	0	
Total	67	2	80	135	165	466	83	27	0	1	0	1026 (19.4)
Direct care												
Assist	0	0	2 (1.2)	23 (12.3)	4 (2.7)	19 (6.9)	4 (5.6)	3 (3.3)	0	0	0	
'Sterile washing'	0	0	0	1 (0.5)	0	0	0	0	0	0	0	
Drape	0	0	0	0	12 (8.1)	4 (1.5)	5 (6.9)	2 (2.2)	0	0	0	
Invasive anaest. procedure	0	0	14 (8.3)	27 (14.4)	7 (4.7)	21 (7.7)	0	9 (10.1)	0	0	0	
Patient care	0	10	153 (90.5)	136 (72.7)	125 (84.5)	230 (83.9)	63 (87.5)	75 (84.3)	0	0	0	
Total	0	10	169	187	148	274	72	89	0	0	0	949 (17.9)
Documentation	2	0	10	7	84	372	37	12	0	0	0	524 (9.9)
In-transit	22	32	10	15	17	23	2	2	0	0	0	123 (2.3)
Pre indirect care												
Disinfect	2 (2.2)	0	0	0	0	0	0	0	0	0	0	
Organise/arrange	46 (49.5)	1	0	0	0	0	0	0	0	0	0	
Control/check	1 (1.1)	0	0	0	0	0	0	0	0	0	0	
Read	31 (33.3)	0	0	0	0	0	0	0	0	0	0	
Clean	9 (9.9)	0	0	0	0	0	0	0	0	0	0	
Protect	4 (4.3)	3	0	0	0	0	0	0	0	0	0	

Continued

Table 1 Continued

Process phase, n (%) task categories Subcategories, n (%)	Preoperative preparation	Meeting with the patient	Preparation for anaesthesia induction	Anaesthesia induction	Preparation for anaesthesia maintenance	Maintenance of anaesthesia	Preparation for extubation	Extubation and transfer	WHO sign in	WHO time out	WHO sign out	Total n (%)
Total	93	4	0	0	0	0	0	0	0	0	0	97 (1.8)
Other	4	2	1	3	3	49	4	0	0	0	0	66 (1.2)
Supervision	10	0	11	3	8	20	2	0	0	0	0	54 (1.0)
Total, N	255	57	458	570	896	2348	393	245	20	27	22	5291

The order of the task categories is based on number (n).
RNA, registered nurse anaesthetists.

Observable interruptions were common, and RNA left the OR to retrieve necessary equipment and medications, prior to the patient's arrival. Interruptions may thus be expected and even necessary, rather than unwanted, as they were related to the task at hand.[32] Preparation before anaesthesia through organising the work environment, creating a plan for the patient and undergoing mental preparation may be a way to decrease the number of unnecessary interruptions during anaesthesia. This may contribute to creating safe care through increased readiness to respond to both expected and unexpected events during intraoperative anaesthesia care.[47] If no nursing student was present and supervision was not required, the preoperative preparation was mainly performed independently, which could explain the rarity of multitasking. Given the cognitive load, it could be beneficial to assign the supervision of students to experienced staff, for whom multitasking may be easier to manage.[58]

Preparation for anaesthesia induction was prone to high task intensity and multitasking. There were somewhat fewer interruptions than during preoperative preparation, but a lot of interaction with other members of the team and with the patient. Successful teamwork has a major impact on patient safety, requiring coordinating, reaffirming[47] and assertive communication when sharing information.[59] RNAs' ability to adaptively coordinate their activities during routine situations as a part of the surgical team may support the management of non-routine events.[60] Non-technical skills, such as task management, team working, situational awareness and decision making have been identified as prerequisites for sustaining safe task performance.[44] Hence, in RNAs' work, non-technical skills could support the management of phases with high task frequency, multitasking and interruptions.[61]

Anaesthesia induction

Anaesthesia induction has been identified as a safety-critical phase.[2 9 40] In this study, the highest task frequency for RNAs was during anaesthesia induction. The same phenomenon has previously been observed with anaesthesiologists in simulated situations,[2 6 9 62] confirming that induction may be equally intensive for the entire anaesthesia team. In this study, the frequency of interruptions was high during anaesthesia induction. RNAs' work was ceased because of equipment-related and procedure-related issues. In addition, phone calls were answered, which are known cause a high level of disturbance in terms of consequences and duration.[32] Interruptions may present a threat to situational awareness and prospective memory, both of which are required when continuously monitoring tasks, detecting changes and sharing information with the a team.[63]

Interruptions during induction have been reported in previous studies on RNAs and anaesthesiologists as a team[32] and on anaesthesiologists.[29 38] However, in other studies,[38 41] the most interrupted phase of anaesthesia was emergence, not induction. In these studies, induction occurred in a separate induction room, while in our study

Table 2 Frequency of tasks, total multitasking time and multitasking as a proportion of the total phase-specific observation time in RNAs' intraoperative work process

Phases of RNAs' intraoperative anaesthesia work process	Total phase-specific observation time, hours and minutes	Frequency of tasks (n/hrs)	Total multitasking time, hours and minutes	Multitasking time as a proportion of total phase-specific observation time
Preoperative preparation	4:50	53	1:21	27.9%
Meeting with the patient	1:15	47	0	0
Preparation for anaesthesia induction	5:49	79	3:36	61.9%
Anaesthesia induction	5:49	98	2:57	50.7%
Preparation for anaesthesia maintenance	10:25	86	8:21	80.2%
Maintenance of anaesthesia	36:02	65	22:53	63.5%
Preparation for extubation	4:48	85	2:56	43.1%
Extubation and transfer	3:15	79	1:55	60.0%
WHO Sign in	0:14	*	0:08	57.1%
WHO Time out	0:28	*	0:17	60.1%
WHO Sign out	0:13	*	0:07	53.8%
Total	72:59	72	45:23	62.3%

*Not possible to calculate.
RNA, registered nurse anaesthetists.

the patient was already in the OR when anaesthesia was administered. This highlights the impact of the work environment and its design on patient safety. So-called 'sterile cockpit thinking' has been suggested as an alternative when a separate room is not an option.[64] This means that the entire surgical team has to acknowledge and respect other team members' work phases, when interruptions and unnecessary multitasking could cause risks and deviations to a patient's care process.[39 41 65]

Anaesthesia maintenance

For the most part, RNAs independently conducted the preparation for anaesthesia maintenance. Both the task frequency and the interruption frequency were high, as

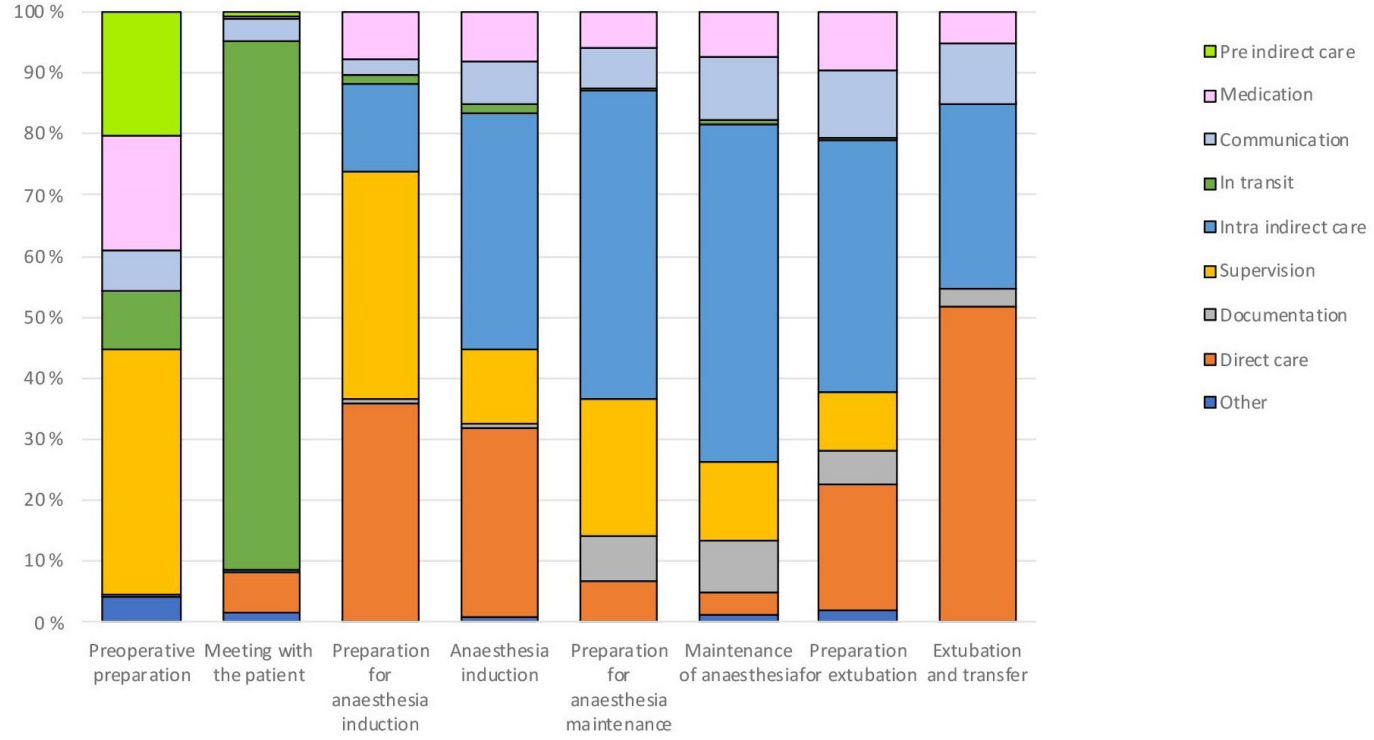

Figure 1 Proportions of category-specific task times in the RNAs' intraoperative anaesthesia work process. RNA, registered nurse anaesthetists.

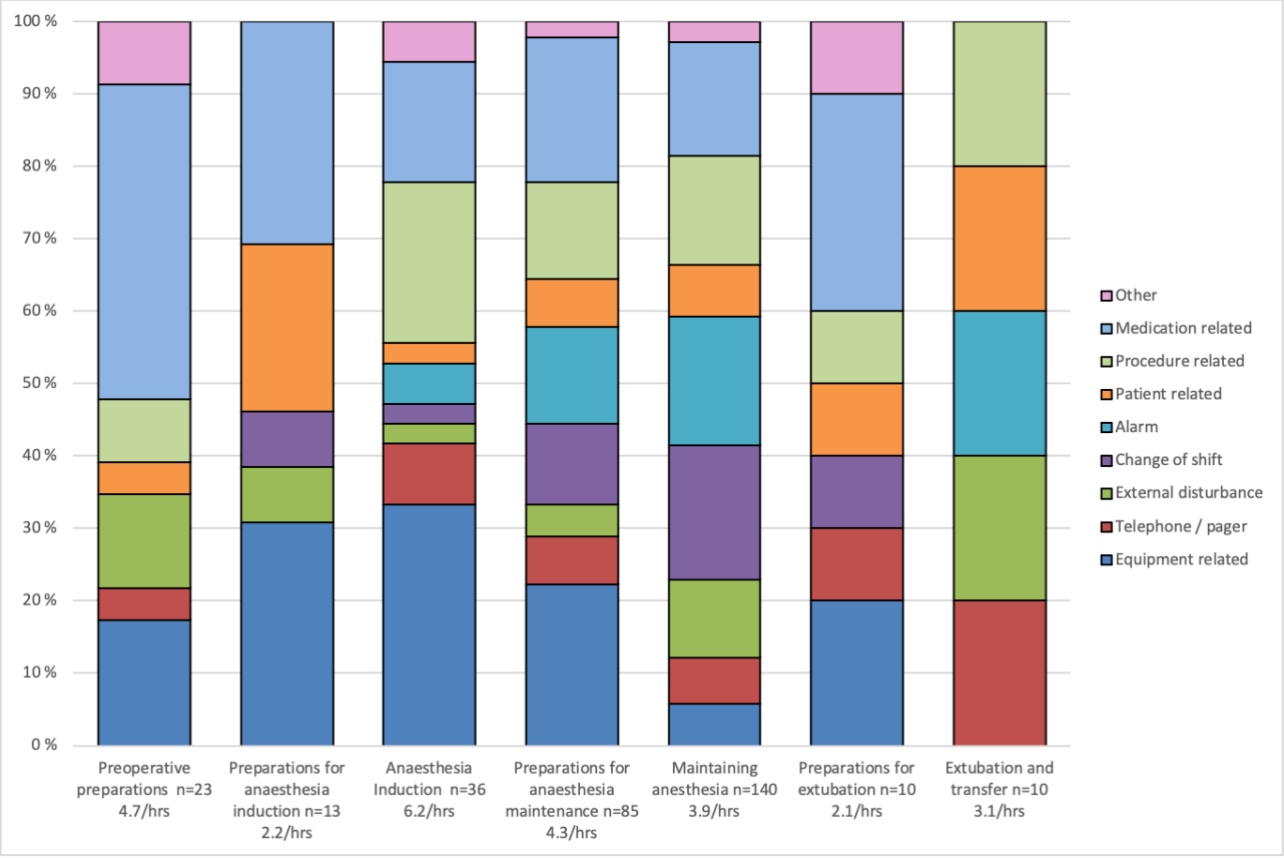

Figure 2 Proportions, number and frequencies of causes of interruptions in the phases of the RNAs' intraoperative anaesthesia work process. Note—no interruptions were observed during the phase 'meeting the patient', hence it is not included in the figure. RNA, registered nurse anaesthetists.

also identified in Al-Hakim *et al*; this phase also had the highest proportion of multitasking.[29] This may reflect the requirements of the phase, where tasks need to be performed immediately and cannot be delayed. Multitasking can also be a consequence of interruptions[29] or may reflect the need to perform more effectively during a shorter period of time, due to increased production pressure.[30] If avoidable and unnecessary interruptions could be minimised, the surgical team could have a greater cognitive capacity to respond to complexities when needed.[29]

Extubation

During preparation for extubation, the frequency of tasks was elevated again, and the amount of multitasking was also high. In contrast to this study, emergence was the most disturbed phase in a study by Campbell *et al*,[38] with the noise level being significantly higher during emergence than during induction.[38] Extubation has been identified as a safety-critical phase,[38 41] during which RNAs need to be a step ahead and the rest of the surgical team should respect the importance of the moment.[46] Thus, sterile cockpit thinking[41] could be beneficial also at the end of anaesthesia. The need of RNAs to focus on the safety-critical task at hand could be highlighted outside the OR too, possibly with the help of IT solutions. This could be achieved with a screen showing the work phases. Patient safety could be enhanced by marking the start and end of a critical phase, during which interruptions should be avoided and no one should enter the OR without a valid reason.

Coordination of the anaesthesia care process

In this study, RNAs communicated often and using short time frames, with professionals in OR and with external units, reflecting their coordinating role in surgical team. This could indicate an active approach to managing the complex everyday work, which requires anticipating, responding, monitoring and adapting based on the needs of the team and the patient.[66] Conducting phone calls (n=116) as a part of professional communication may be imperative for the smooth delivery of the perioperative process and enhance preparedness for the next phase in the process. Another sign of coordination was the brief moments RNA needed to leave the OR in order to retrieve something missing from the preparation room. These in transit—tasks (n=123) appeared in every phase, including anaesthesia induction. However, especially during a safety-critical or task-intensive phase, such as anaesthesia induction, preparation for maintenance, extubation or an unexpected acute situation, calls and retrieval of medication or equipment needed could be

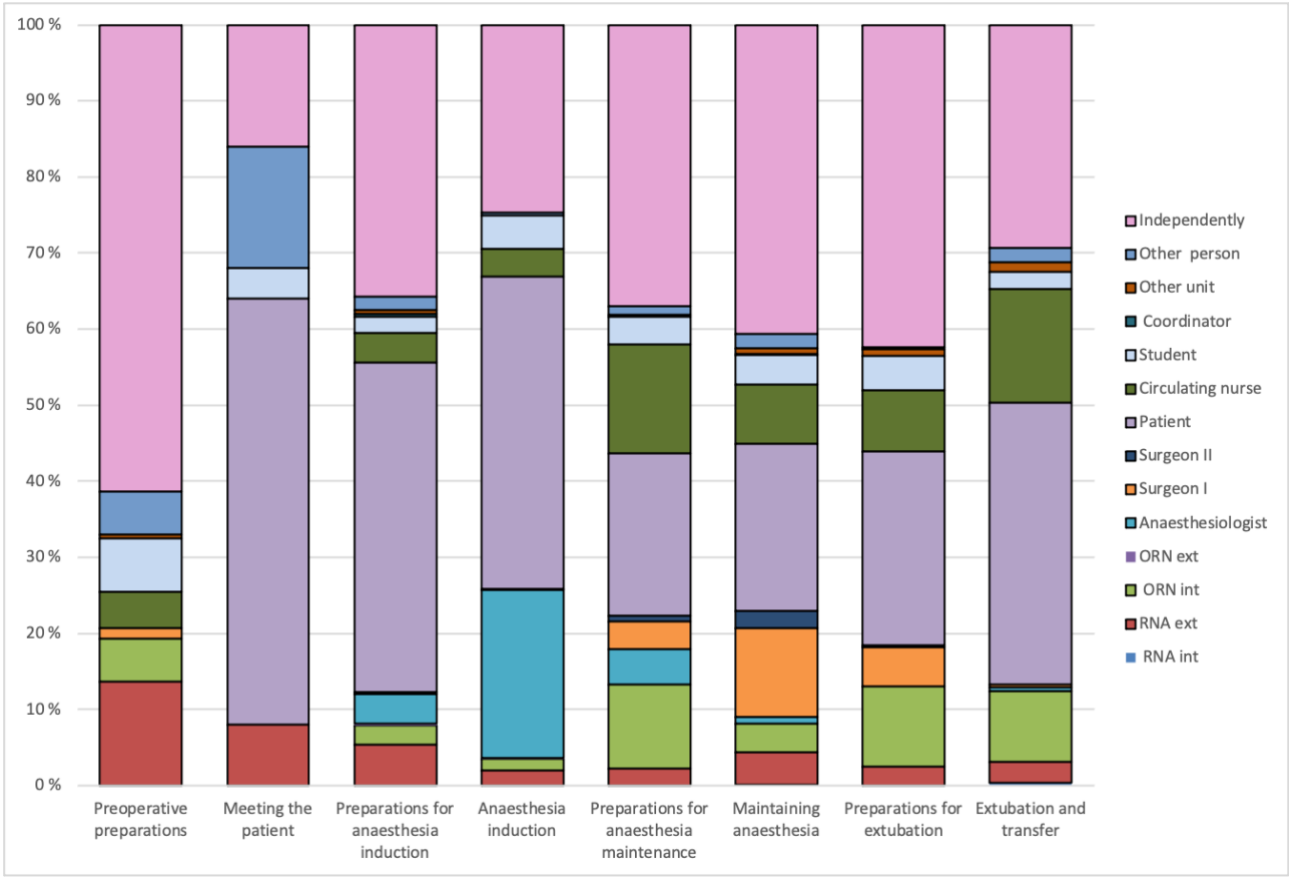

Figure 3 Proportions of time that RNAs spent in independent work and in interaction with other professionals and patients during the phases of the intraoperative anaesthesia work process. RNA, registered nurse anaesthetists.

delegated to other members of the surgical team, such as the circulating nurse. In addition, thorough preparations before anaesthesia may ensure the adequate amount of necessary appliances in the OR.

The dual nature of multitasking

Multitasking is an inherent part of intraoperative anaesthesia care and should be embraced as such. Some professionals view multitasking as a professional skill, not as a strain.[21] Successful management of multitasking requires professional experience[67] and the ability to adapt to rapidly changing situations while simultaneously ensuring the seamless progress of anaesthesia care. However, recent research on the effects of multitasking[67] shows that it increases complexity and cognitive load, and the inherent risks should be acknowledged. Unnecessary multitasking should be avoided, especially during safety-critical phases such as anaesthesia induction and extubation. Management could use assessment of the amount and quality of multitasking as a leading indicator of potential safety issues, when work actually done in anaesthesia is drifting too far from work as planned.

Management

RNAs have a pivotal role in managing the complexity in a CAS and sustaining patient safety together with the surgical team. However, managerial decisions and culture at the organisational level have implications on the complexity at the sharp end, where work is actually done, as well as effects on the adaptive capacity of the frontline.[68] High demands on production or time pressure may increase the workload and push professionals to undertake avoidable multitasking. Our study shows that there are aspects of the RNAs' contributions to resilient performance of surgical team tasks that could be harnessed by observing the natural, case-related variation of tasks, multitasking and interruptions. This could aid in organising healthcare to support resilience. However, we have also described examples of how the RNAs' attention can be consumed by adaptations needed to cover the consequences and unnecessary complexity of a poorly designed system.[63] Detailed description and analysis of tasks, multitasking, interruptions and their causes, and interactions during the different phases in the RNAs' work process may provide insight into risk-prone situations. This could elucidate options for organising healthcare to close the gap between the work as planned and the work as done and thus protect the capacity of RNAs to contribute to resilient performance.

Strengths and limitations

This study adds to the knowledge on RNAs' intraoperative work, including tasks, multitasking, interruptions and

their causes, and interactions, illuminating the varying intensity across different phases of intraoperative anaesthesia care. The data collection tool used, WOMBAT, employs a structured observation protocol with an operationalised definition of 'interruption', which may reduce the risk of potential measurement errors. However, the number of RNAs observed was relatively small, limiting the representativeness. In addition, some participants were observed on several occasions, which may imply a risk of systematic bias. On the other hand, the unit of observation was the RNAs' work process, which depended additionally on the ongoing operation and the operating environment. Generally, this could decrease the impact of the individual nurses observed. This study was performed at one hospital only and the observations did not include night shifts, weekend shifts or procedures conducted on Fridays, which may limit the representativeness for different work shifts and reduce the generalisability of the findings. It should be acknowledged that as the phases were constructed after the original data collection; some tasks with long duration may extend across two or more phases, making the frequencies and proportion of times an estimate. This was especially evident with respect to supervision, as this continued throughout the entire intraoperative anaesthesia work process.

CONCLUSION

This study adds to the knowledge from previous research by illuminating how RNAs' work is actually done, uniquely mapping the different dimensions of work in relation to the intraoperative work process and thus giving further insights into the context and challenges for safe practice. As the core of anaesthesia care and thus the safety-critical moments are the same regardless of context, this study presents possibilities for learning regarding how to reduce the occurrence of unnecessary interruptions and disturbances in RNAs' intraoperative work. Phases more prone to unnecessary multitasking and interruptions, especially those that are critical for the patient and cognitively demanding for the RNAs, should be acknowledged and their safety ensured. This should be taken into consideration already in planning the processes, taking account of the management, surgical team, work environment and available resources. The results can also contribute to development of training by elucidating safety-critical moments, threatened by untimely multitasking or interruptions. This knowledge suggests specific timing for the use of non-technical skills and could also guide the design of safer work practices specifically tailored to safety-critical intraoperative phases. Multitasking and interruptions being seen as threats to safety in anaesthesia care, they could be interpreted as signs of the adaptive capacity of a complex system, reflecting resilience. Further studies exploring this adaptive capacity of RNAs in managing the intraoperative anaesthesia work process, multitasking, interruptions, and interactions may give insights into how RNAs could make note of and act on situations that introduce a risk.

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