Coordination in Perioperative Systems – A Tacit View

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ABSTRACT
Coordination of perioperative systems is a deeply collaborative process, distributed over time and space. The paper analyses coordination in a perioperative centre along the three temporal levels suggested in [1]: allocation, scheduling, and synchronization. In particular, the tension between schedules and actual demands in synchronization work is reflected by looking at example situations. It is shown how dedicated coordination workers try to find a balance between different co-existing values and goals of all stakeholders. Their abilities to analyze a situation, to negotiate problems and to react flexibly are needed in systems such as modern hospitals. It has to be taken into account in systems design.

Keywords
Collaborative and distributed healthcare, temporal coordination, invisible work, resilience.

FRAGMENTS...

{F1} "Perioperative systems design describes a rational approach to managing the convergent flow of patients from disparate physical and temporal starting points (frequently home), through the operating room (OR), and then to such a place and time (home or hospital bed) where future events pertaining to the patient have no further impact on OR operations. This process for an individual patient can be envisioned as a nested set of timelines: a coarse-grained timeline beginning with the decision to perform an operation and ending when the patient definitively leaves the postoperative experience, and a fine-grained timeline encompassing the immediate pre-, intra-, and postoperative course... Perioperative systems design can be conceptualized, studied, and optimized like any industrial process in which many materials, actors, and processes are brought together in a coordinated workflow to achieve a designed goal" [7].

{F2} According to the business manager of OR Soft Jänicke GmbH, business directors of big hospitals wish to consider the throughput at a hospital in a holistic way to aim for meeting lower length of stay during planning at least. This can be achieved if data are promptly recorded. The application of the "Patient Manager" makes it possible to achieve this goal. By using "Treatment Patterns", the system is able to plan even before the admission of the patient to the clinic. (Treatment patterns are simplified clinical paths reduced to the description of the medical service and needed resources). The Patient Manager allocates automatically beds and time slots for examinations and operations. The system automatically fills in a variety of forms. Algorithms guarantee the availability of time slots and the absence of conflicts (translated from [4]).

{F3} The mother of the first author told her that their neighbour, a 69-year old woman, had to undergo a surgery this winter. She packed her bag and went by taxi (paid by the health insurance) to the hospital in the other town. However, after the examinations for the operation the following day she was told to go home and then come back next morning. She was not prepared for this situation, had to call another taxi (and a third one next morning) and spent an uneasy night alone at home. When talking with the nurses about these new practices they told her about a man in a similar situation whose bus was too late. When he finally arrived at the hospital he was chilled to the bone and not ready for operation. It had to be rescheduled.

{F4} "Well-defined processes enhance mutual understanding of all parties involved in the perioperative care. When each person involved has a clear understanding of his responsibilities and duties, the process can run efficiently" [5].

{F5} "Operating rooms are regarded as the most costly hospital facilities. In this context several strategies have been proposed that optimize patient throughput by redesigning perioperative processes. The successful deployment of effective practices for continuous process improvements in operating rooms will require that operating room management sets targets and monitors improvements throughout all phases of process engineering. Simulation can be used to study the effects of process improvements through novel facilities, technologies and/or strategies" [2].

{F6} "According to Valgårda (1992), the arguments behind the evolution of the modern Danish hospital organisation have been based on the production factory as an equivalent analogy. Hence, a rationalistic approach to organisations – as evident in Weberian bureaucracies, Tayloristic management theories, and Fordist rationalization of the production of goods – has also been one of the most influential conceptualisation of organisations and

cooperation within hospitals. This rationalistic organisation of collaborative work emphasises that (i) there is a functional division of work, (ii) the responsibility for organising work should be shifted from workers to management, hence separating planning from implementing work, (iii) control of time becomes the key to control labour, by paying salaries in based on workhours, and (iv) work is production-oriented" [1].

{F7} "The presence or participation of a resident physician prolongs the duration of the surgery up to 70% increasing costs accordingly. Adequate resident training, possibly with the aid of a simulator and experienced assistance should be provided to the residents starting to operate more independently. Even small reductions in operative time can increase OR throughput...Teaching a resident seems to delay the anesthesiologist only by 2–3 min. Covering more than one room statistically causes a delay of 6 min" [5].

{F10} "Intra-organisational coordination requires planning, and sophisticated schedules become necessary to provide a degree of predictability. The operation schedule is clearly an indispensable mediator for temporal coordination at the surgical clinic. However, as pointed out by Zerubavel (1981), one of the most significant consequences of the invention of the schedule has been the consolidation of the element of routine in collaborative work, which is essential antithetical to spontaneity. In general, there is an inherent trade-off between the static quality of pre-set plans and schedules and the dynamic quality of ongoing collaboration" [1].

…of an Introduction

Hospitals are sensitive and well-studied working environments. The above fragments show that they are studied by people with different backgrounds, assumptions, methods and intentions. And of course, they are reflected by people in their everyday life (e.g. {F3}). This paper adds a report about an analysis of coordinating activities in a perioperative centre where different surgical departments share ten operating rooms. Perioperative systems, their underlying rationale and assumptions are explained in {F1}, {F2}, {F4} and {F5}. Their development is critically reflected in {F6} and {F8}. The case study shows how important it is in the current system that coordination workers are able to negotiate and solve problems and to react flexibly to unexpected or only vaguely expected situations. Improvements to the system will have to take into account these aspects.

THE CASE STUDY

The analysis was conducted as part of the Perikles project with two other partners to support "flexible work processes" in perioperative systems.

Objective and Research Approach

The goal of the analysis was to gain a deeper understanding of coordination in perioperative systems. On the one hand, such systems need a sophisticated scheduling of operations and examinations and are mainly measured in terms of operation room throughput. On the other hand, the personnel have to react flexibly to emergencies, complications during an operation or patients who are not ready for the operation. They may be confronted with staffing shortages[1] or a lack of resources. Last but not least, they may be confronted with a mismatch of organisational goals and their own values. We were particularly interested in how people who perform coordination work actually cope with these tensions. How do they use their skills to coordinate the work as smoothly as possible?

The analysis was based on an activity-oriented, tacit conception of work[2]. This view was not fully shared by all participants of the project but helped to counterbalance other interpretations of data. Just to give a small example, we could observe several "methods" the operation manager applied to track the situation in the first floor of the operation suite. For example, she explained: *"The first point in room 1 is finished now. I heard the anaesthetist talking"*. She asked the storage male nurse to do her a favour and check whether room 4 is already dark (meaning here that the operation is almost finished). She was also aware of equipment and patients passing her open office. One interpretation was that this behaviour is error-prone and should be replaced by reliable tracking mechanisms automatically recording relevant points of time[3].

Our work was influenced by studies grounded in conceptual frameworks such as activity theory or distributed cognition, e.g. [1,6,10]. Data collection was conducted from spring 2009 to fall 2010. It involved participative observations (e.g. of the operation manager, the head nurses, the head anaesthetist, a storage male nurse), interviews at workplaces (e.g. anaesthesia consultation, central patient management of the general

[1] "In many countries shortage of anesthesiologists or anesthesia nurses restricts the availability of ORs." [6]

[2] In [9] an "organizational, explicit view" and an "activity-oriented, tacit view" on work are distinguished. While the first perspective conceptualizes work in terms of defined tasks, processes, and work flows to achieve business goals, a tacit perspective focuses on analyzing everyday work practices. Sachs shows general design implications from taking one or the other view. For example, people are rather considered as producing errors and deskilling is desirable in an explicit view. Social interaction is seen as nonproductive. In contrast, people are considered as able to discover and solve problems and skill development is desirable in a tacit view. Communities are seen as funds of knowledge and a system is flexible if people are skilled. Sachs argues that a balance of the two views is needed but rarely achieved in design activities.

[3] In [10], the interweaving of coordination and control in computer-based information systems and possible effects are discussed. "Resources for action should be separated from accounts of action" is recommended in [3]. However, operation management systems such the one in this study show an opposing trend.

surgery unit) and studies of documents[4]. Audio tapes were transcribed. Photographs were taken. Information artefacts such as schedules and allocation plans were collected. Visual materials were processed to remove any patient identifying information. Accumulated data were discussed and analysed in individual work and in group meetings.

ANALYSIS

Within this paper, we focus on some aspects of the analysis only. First, perioperative processes and the studied system are briefly described. Second, the distributed nature of coordination work is described along three temporal levels as suggested in [1]. Third, a glimpse of the work of the operation manager in the study is given by a reflection of situations where she used her skills and spontaneity to respond to actual demands during continuous temporal coordination. We argue that dedicated workers try to find a balance between different co-existing values and goals of all stakeholders. The paper closes with a discussion of how to support the flexibility of systems such as modern hospitals.

Description of the Analyzed System

In perioperative systems, the treatment of patients follows a scheme called *perioperative process*. A short explanation of this model is already given in fragment {F1}. Figure 1 shows typical 'patient movements' with a focus on the fine-grained timeline (see {F1}). The perioperative process in a hospital includes all clinical steps from admission of the patient on the ward, examinations and anaesthesia consultation through surgery (including premedication and anaesthesia care) to care and patient release from hospital.

However, the treatment of a single patient is seen through the lenses of the whole perioperative system which aims to reduce costs. The main goals are maximizing the use of operating rooms (OR) and reducing staff. Hence, most perioperative systems have OR-suites and so called nurse pools for a shared use by different surgical departments. In addition, single ORs consist of different areas for anaesthetic preparation, the actual surgery and emergence from anaesthesia to allow an overlapping of surgeries.

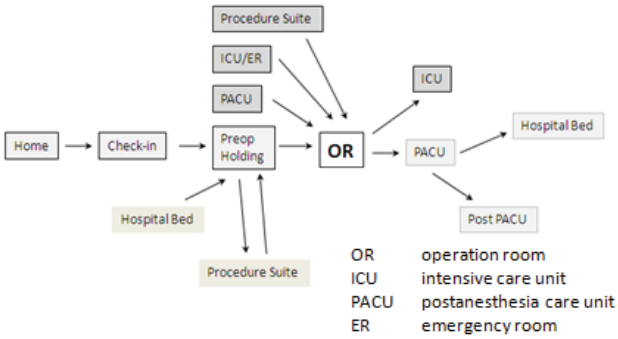

Figure 1. Perioperative movement of patients, in [7].

[4] Interviews were conducted in other hospitals as well. They are not subject of this paper but helped to understand the impact of the specific constraints on the overall perioperative system (e.g. physical constraints, permanent staff shortage and actual division of labour).

Figure 2 partly illustrates the specific situation in the analyzed perioperative centre which is part of clinical centre with different locations. The OR-suite consists of two floors with four and six ORs respectively. The physical layout of an OR and of the first floor is to be seen in the figure. The centre is at the main location of the clinical centre and accommodates many surgical departments, the radiology and the anaesthesiology department with two ICUs. The anaesthetists are in charge of five functional areas spread around the whole clinical centre. Bottlenecks in this system are shortages of nurses, anaesthetists and beds in the ICUs.

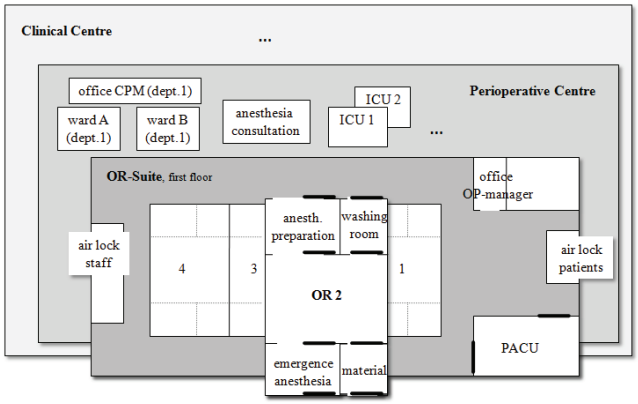

Figure 2. The perioperative centre – overview.

The coordination of the perioperative system is a deeply collaborative process, distributed over time and space. Some members of the staff are exclusively concerned with coordination tasks to ensure a proper treatment of all patients. Other people such as the head surgery nurse, the head anaesthetic nurse and the head anaesthetist in the OR-suite coordinate the work of their co-workers but are also involved in the actual surgeries.

At the time the participative observations were conducted, an operation manager (OP-manager) was responsible for the coordination of work in the OR-suite. She was directly responsible to the head of the clinical centre. For reasons of brevity, the description of coordination work is mainly restricted to the central patient management (CPM) of one department with two wards (called department 1, ward A and ward B), to the anaesthesia consultation (AC) and to the work of the OP-manager. This is indicated in Figure 2.

Distributed Coordination of Perioperative Processes

On the one hand, distributed collaborative coordination helps to consider multiple interests by gradually shaping future activities in a working system. On the other hand, coordination is an activity itself and participants develop activity rhythms which have to be coordinated as well. This also includes the development and appropriation of artefacts. In the example, all coordination work is constrained by the organisational goal to achieve a high throughput through the ORs. More specifically,

– Two nurses in the CPM are responsible for the inpatient planning of department 1. This includes appointments for necessary examinations and anaesthesia consultations, if possible prior admission at the ward.

– The nurse in the AC has to organize appointments with anaesthetists for the perioperative centre and other departments of the clinic to ensure that all patients had a consultation at least 24 hours before the operation.

– The OP-manager has to schedule operations for the next day and to synchronize actual activities in the OR-suite.

In the first case, the urgency of an operation is considered but also time constraints of doctors and patients. It is aimed for reduced costs of the wards and less waiting time for patients. In the second case, the safety of the patients during the surgery is in the focus of interest. The OP-manager has to consider, for example, the demands of all surgery departments but also has to act in the interests of the staff in the OR-suite[5].

We apply the approach taken in [1] and describe aspects of coordination along three macro-temporal levels of collaborative work: *synchronization* (continuous temporal coordination), s*cheduling* (planned temporal coordination), and a*llocation* (coordination temporal motives).

Scheduling

Figure 3 sketches some schedules with different time granularities and different level of detail as they are created and used by different stakeholders. They are indicated by encircled numbers.

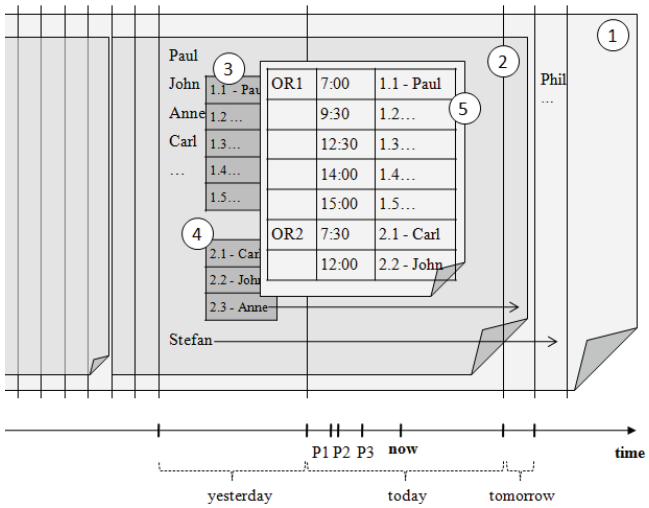

Figure 3. Different schedules in use: long-term schedules, weekly schedules, and days schedule of the OR-suite.

(1) is a long-term schedule maintained by the nurses in the CPM. It contains appointments for operations of department 1 planned up to several months in advance because this department has many elective patients. The nurses use a blackboard, their own software system, printouts and paper for scheduling. (Other departments use e.g. operation books as described in [1] and Excel for planning.)

(2) Every Friday, the CPM nurses send their operation schedule of next week to the OP-manager (by fax) and the weekly lists of admissions to the wards A and B. *"Always only for the next week...Something can change though. A new patient can come. Okay, the ward will tell her [the OP-manager] that. Or, a doctor realizes that he doesn't need to operate this patient. This is only a preview. She gets the real [plan] every day from the wards."* (nurse CPM)

(3),(4) The wards inform the OP-manager every day (officially until 11:00, often between 11:00 and 12:00 due to work overload) about their surgeries planned for the next day by registering them in the central management system (called CoMed here).

(5) The OP-manager uses CoMed to create the next day's schedule for OR-suite usage (day plan). A first and second version is given e.g. to the wards, the AC, labs (fax), head anaesthetist, head nurses, storage male nurses and cleaning service (printout). She pins a printout to the wall outside her office. *"There, the nurses already take a look and prepare themselves for tomorrow. And also the surgeons, when they have a break, take a look at tomorrow."*

Allocation

Allocations can be considered as long-term agreements on the usage of shared resources. They often have a rhythmic structure to support their internalization by collaborators. An example is the allocation plan of the OR-suite which has existed for many years. It says, for example, that trauma surgery can use OR1 on Mondays from 8 to 14, that OR3 and OR4 are always reserved for heart surgery, that OR6 is a "long table" every Thursday and so on. An exemplar of this plan hangs in the office of the OP-manager (Figure 4) but is internalized by her.

Allocation is important for constraining scheduling problems. Another example is reflected in the following explanation of a CPM nurse: *"Monday is visceral consultation, Dr. X cannot be in the OR then. Dr. Y is here in the consultation on Tuesday. He makes small surgeries, laparoscopic galls, hernia and so on, we cannot check in him on Tuesday..."* Due to their stability allocation plans can also cause permanent conflicts. For example, a mismatch between the OR allocation plan and the actual needs of a surgery department developed in the studied system because that department grew larger.

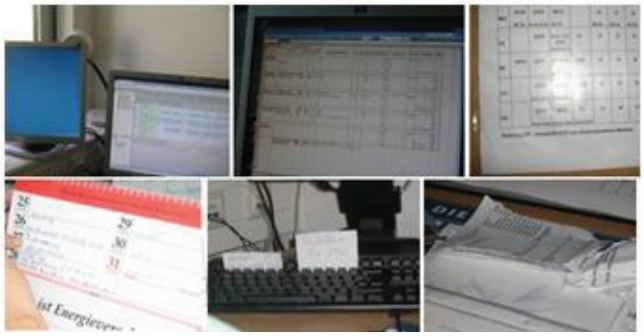

Figure 4. Artefacts of the OP-Manager. Top: CoMed system, preview of weekly schedule of a department (Excel), OR allocation plan. Bottom: paper calendar for prebookings (e.g. ICU beds), notes, "done".

[5] A big calendar sheet is pinned to the wall in her office quoting Laurence Sterne: "The art of drawing up a budget is to spread the disappointments evenly." (transl.)

Synchronisation

Synchronisation is fine-grained temporal coordination and is prepared by scheduling. For example, the nurse in the AC is waiting for the day plan at lunchtime (first version) in order to select at least those of the patients waiting for an anaesthesia consultation who will be operated the following day. "*That's why I always push a little bit. With her [OP-manager] it works very well. If she has a substitute, I have to push sometimes. OK, they are substitutes."*

In Figure 5, three "instances" of the day plan are shown which serve to coordinate the actual events in the OR-suite. On the left, part of the day plan is hanging in an OR. The printout was annotated and copied by anaesthetists during their afternoon meeting the other day to convey important information about patients to colleagues. The screenshot detail in the middle illustrates how the CoMed system helps to keep track of events. The staff members have to enter relevant points of time of each perioperative process (e.g. patient enters OR suite, patient in OR, surgeon arrived, begin blood arrest...).

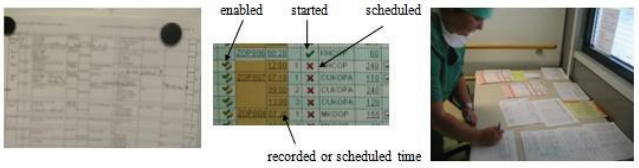

Figure 5. "Instances" of the day plan for synchronization.

The picture on the right shows the so called "table of anaesthetists" in the floor of the OR-suite with different forms and a printout of the day plan which is continuously annotated by the OP-manager to show the course of events.

A Glimpse of Continuous Temporal Coordination

Although the actual course of events in a perioperative system is shaped a great deal by schedules, there are often unexpected or only vaguely expected situations. Emergencies and complications during a surgery can happen anytime. As another example, schedules are known as being too optimistic very often [5]. Communication plays an important role for establishing relationships, shared understanding and commitment. This is needed to be able to respond adequately to the demands in this working environment. Two interleaved "small" situations which required flexible behaviour are described from the perspective of the OP-manager (in the following called OM).

Situation 1: Rescheduling of 3.3

Five surgeries were planned in OR3: point 3.1 at 7:00[6], point 3.2 at 9:30, 3.3 at 12:30, 3.4 at 14:00 and 3.5 at 15:00. All surgeries were planned by the department which permanently lacks of OR capacities. The second point started very late. OM was called at 12 o'clock by the surgeon of point 3.3 asking her whether they couldn't operate this patient in parallel in another OR.

- [12:20] OM calls the head nurse. She tells her that the point in OR4 is almost finished and asks whether they could move point 3.3 to OR4. *"I would call him [the patient] then. OK, let's say he will be in the room at three quarter to or even at one. Thanks. Bye."*
- OM calls a ward but the patient is at a different ward.
- OM calls and asks whether OR4 is now ready.
- OM calls the other ward and asks them to premedicate the patient and bring him to the OR-suite[7].
- OM goes to OR4 and informs them about the movement of 3.3 to OR4.
- Head nurse and OM are looking for a team for OR4.
- OM is back in her office and enters the movement of 3.3 into the CoMed system.

Situation 2: "Emergency heart"

OM sees in the morning that the heart surgery expects to operate an "emergency heart" today. She opens the weekly plan of the department to get more information about patient H who will come by helicopter. She looks for H in the CoMed system but can't find the patient. She knows from experience that there can be a spelling mistake in the name. She thinks that she will need an additional ICU bed.

- [9:30] OM talks with the head anaesthetist (HA) about "the heart" and that the arrival is not to be expected too soon.
- [10:30] OM calls ward W and ICU, but H is not there.
- [11:30] OM calls ward W, H hasn't arrived yet. But the nurses will call her back.
- [12:05] A doctor calls OM and tells her that he can hear the helicopter. OM tells him to bring H to the ward for preparation. OR5 will be ready soon.
- [12:30] OM calls ward W to be sure that H has arrived.
- [12:34] HA comes and asks OM whether H is at ward W or at the ICU.
- OM calls a doctor for the surgery of H.
- OM (still at the phone) and HA decide to premedicate H in the OR-suite and not send an anaesthetist to the ward in order to save time.
- OM explains to the doctor on the phone their decision to have him earlier in the OR suite.
- [12:39] OM calls the nurses in OR5 and prepares them for the next steps.

In the first situation, the OP-manager knows that the late point in OR3 will likely result in the cancellation of an operation. She also knows that this department generally needs more OR capacity. When the surgeon calls her she initiates the formation of an OR team. She knows that this means extra work for the nurses and helps them.

In the second situation, the OP-manager needs to coordinate an additional operation with a high priority. She has to keep track of the situation to prepare her colleagues. The doctor who informs her about the arrival of the helicopter is aware of her role in the overall process. The OM and HA decide to modify the premedication process in the interest of the patient and the nurses who otherwise will probably have to work overtime. They have to do it too often.

DISCUSSION

Flexibility by or despite Information Technology?

At the time of the analysis, a central management of patients and the coordination of perioperative processes were partly supported by the system CoMed. The nurses in

[6] A surgery in the OR-suite is also called point. 3.1 refers to the first surgery of the day in OR3, 3.2 to the second etc.

[7] Normally, the nurses would call the ward.

the CPM of department 1 and in the anaesthesia consultation were promised to get access to the system as well. The information system's infrastructure was heterogeneous. For example, anaesthetists had to enter some data multiple times into different information systems (additionally, handwritten documents are required in some cases). They had no direct access to archived data of patients. We often observed that people were wondering what of the information they have access to can be accessed by colleagues using CoMed in a different role. For each perioperative process relevant points in time had to be recorded, but were sometimes not promptly entered.

A more homogeneous information structure certainly improves the quality of the whole system. The operation manager may work more efficiently if CoMed would record some more relevant points of time. The nurses in the CPM and AC criticized that they did not get enough information about cancellations of operations. In a more matured management system, such information could "flow back" to them. However, flexible systems require a healthy co-development of skilled workers and new information technology (e.g. [8]). From our point of view, the interdependencies of distributed activity cycles concerning scheduling and synchronisation of perioperative processes have to be understood much deeper. What makes planning more robust? For example, scheduling includes negotiating and ensuring commitment of collaborators [1]. Too restricted synchronous communication for scheduling may affect continuous temporal coordination as well.

Smart scheduling also means to find an appropriate level of detail of plans. It does not make much sense in the analyzed system to plan with an exact number of free beds in the two ICUs. If necessary, some patients have to be moved to the PACU in order to have ICU beds available. And this is a matter of negotiating and problem solving. A revision of concepts such as "complete" or "precise information" which often guide the design of management systems (see e.g. {F2} in the introduction) may be useful.

Invisible Work?

The studied system was often described to us as "chaotic". Indeed, there is a high turnover among nurses and anaesthetists. In this paper, we could only touch on activities and attitudes of some of the coordination workers. Their dedicated work maybe often remains "invisible". The nurses in the CPM realized e.g. that doctors often do not have enough time to find out side diseases of patients. *"And then we ask here and hear stories! That we sometimes have to send the patient back to the doctor and the doctor thanks for that… you just have to talk with each other."* The situations described in the previous section reveal the ability of the OP-manager to respond spontaneously to actual demands and to make decisions in order to support colleagues and patients. The importance of this ability is pointed out in {F8} (introduction). We could also observe the OP-manager giving colleagues background information or preparing them for their next task. This awareness is only achievable by experience and deep reflection.

SUMMARY

Surgery environments are dynamic and high risk. "They require coordination across multiple groups whose incentives, cultures, and routines can conflict" [6]. Perioperative systems even increase the coordination effort and the potential for conflict. A system can be considered as flexible if it allows achieving multiple goals with varying priorities according to the actual context. The presented study analysed coordination work in a concrete perioperative system. The need for workers who are able to react flexibly and negotiate problems has been revealed. We think that a too strong focus on the improvement of information systems does not necessarily result in more flexible systems. This requires the co-development of skilled and dedicated workers and technology.

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