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ECONOMIC ANALYSIS OF PERIOPERATIVE SURGICAL PROCESSES

ABSTRACT. *Background*: Improving clinical pathways, especially in operating rooms (OR), is important for the success of a hospital.
Objectives: (a) To analyze time-related perioperative pathways; (b) to identify delays focusing on (i) anaesthesiological process-times, (ii) vacancy of the OR and (iii) the validity of the surgery-planning.
Methods: A time study was conducted to assess perioperative processes. Accurateness, variation and duration of surgeries were assessed using hospitals schedule for surgeries.
Results: 239 perioperative processes were assessed. Average durations of pre-operative, operative and post-operative processes were 7min, 64min and 8min, respectively. Mean time in which the patient was unnecessarily anesthetized was 2min. Average vacancy of the OR was 48min. Stability of schedule valued 78%. Average cutting time was 23 min after schedule. 77% of surgeries were more time-consuming than scheduled.
Conclusions: The key challenge is to optimize the schedule stability and the precision of durations, which is important to prevent vacancies.

Keywords: perioperative management, surgical processes, organization and management, anaesthesiological and surgical ratios.

Introduction

The health care sector in Germany is facing several challenges in recent years. These mostly restrictive legal actions are answered by the hospitals using cost-cutting instruments, like outsourcing, reducing personnel or even closing inefficient departments. Nevertheless, it has shown that these rationalization potentials are predominantly exhausted. Therefore, for hospitals it is highly important to focus more closely on the structure of treatment processes, which is one of the keys to hospitals success. By continuous reconsideration of hospital organization, which is beside the holistic view of the patient´s treatment, process management (PM), which is described as planning, organizing and controlling measures to provide a purposeful control over hospital performance (Dahlgaard and Stratmeyer, 2006) can provide a substantial improvement of the treatment at all (Zapp, 2002). The objective of PM is to secure and improve the economic competitiveness of a hospital. Furthermore, it intends to increase the quality of treatment and decrease costs (Zapp, 2002). Particularly in the cost-intensive surgical area, where up to 35% of hospital´s budget is generated and on average cost per hour between 650 and 800 Euro arise a PM is needed. In the operating area, PM furthermore tries to increase the quality of surgical performance and to stabilize planning and calculation of these surgeries (Greiling, 2005 and Zapp, 2002). Thus, there is a need of the analysis of the resources used and the time-related processes of a hospital to overcome the cost pressure and to achieve efficient use of the operating room (Boldt, 2009). However, little is known about the time-related perioperative processes of hospitals and the resources used for these processes. Thus, the objectives of this analysis were (1) to analyze the time-related preoperative, operative and postoperative clinical pathways of a general hospital concerning the quality of the patient´s treatment focusing process delays. Furthermore, the aim was (2) to identify delays in processes and the vacancies in operating rooms as savings potentials for cost to improve the efficiency of the hospital focusing on (i) anaesthesiological process-times, (ii) OR-changing-time/ vacancy of the OR and (iii) the validity of the planned surgery in comparison with real times of surgeries.

1. Methods

1.1. Study design

The present study is an analysis of the time-related perioperative processes of a general hospital of Mecklenburg-Western Pomerania. The investigated general hospital with its less than 200 beds in total consists of six medical departments, surgery, internal medicine, gynecology, anesthesia and intensive care medicine, pediatrics and the department for ear-nose-throat disorders. The OR-capacity of the hospital consists of three operating rooms, which normally are operating from 07.30 a.m. until 3.30 p.m. The analyzed treatment process covered the entire perioperative process from patient's entrance and registration in the hospital to the entrance in the ward after the surgery. To analyze and measure the perioperative treatment process the whole process was divided into three main parts – first the pre-operative-section, second the operating-section and third the post-operative-section (illustrated in *Figure 1*). The pre-operative-section included the inpatient admission and the transportation to the operating area. This process was followed by the transportation of the patient into the operating room. All activities before, during and after the surgery until the transfer to the different wards of the hospital were related to this operating-section. The post-operative-section included the transportation back to the ward.

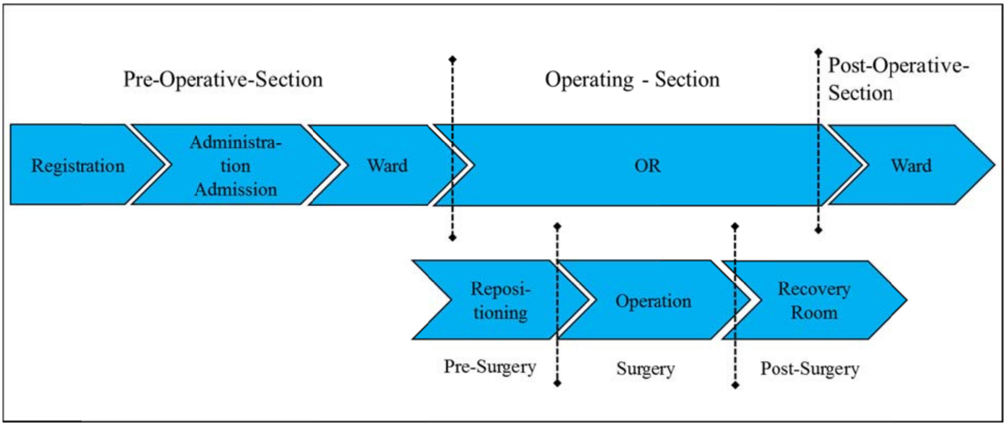

Figure 1. Treatment process of outpatient and inpatient patients.
Source: Own.

The data of the three main processes were collected within four weeks using the time measuring method. In the pre- and post-operative-section the time measurement was conducted by two persons. The treatment processes in the operating-section were collected within a full sample survey of the time-related processes by eight persons taking measurement covering all surgeries of the hospital between 7.30 a.m. and 3.30 p.m. The time survey was carried out by using the progress timing method. Waiting times and other interferences were additionally collected by using single timing method. To be able to make additional statements concerning the surgery-planning-model all short and medium surgery-occupancy plans were documented during the survey and compared with the real measured process times. Finally, anaesthesiological and operative indicators were calculated and compared to similar studies in comparable hospitals.

1.2. Outcomes

The main outcomes of this analysis were the time duration of the pre-operative, operative and post-operative processes, as well as the following key figures of the operative processes: (i) the anaesthesiological process-times, (ii) OR-changing-time, which is similar to the vacancy of the OR, (iii) the validity of the surgery-planning in comparison with the real times of surgeries.

For a further description and definition of the used indicators, please see Bauer *et al.* (2008) and Lübbe (2010) (Bauer, 2004 and Lübbe, 2010).

2. Results

In total 239 process times were measured, which were subdivided into 120 full surgeries and 119 processes in the pre- and post-operative-section. The completely documented perioperative treatment process is shown in *Figure 2*, *Table 1* and *Table 2*.

2.1. Pre-Operative-Sector

The average process duration of the inpatient admission was 6min38sec (±6min00sec) until the patient after his arrival on the ward could be moved into his room and prepared for the surgery. For 67% of the patients the admission process could be conducted directly by the ward´s personnel.

In this section, patient's average waiting time was depending on the time of arrival. Higher waiting times of up to 13 minutes were measured for patients who arrived the ward before their scheduled appointment at 7.00 a.m. The distribution of the average waiting times to start the admission process is illustrated in *Figure 3*.

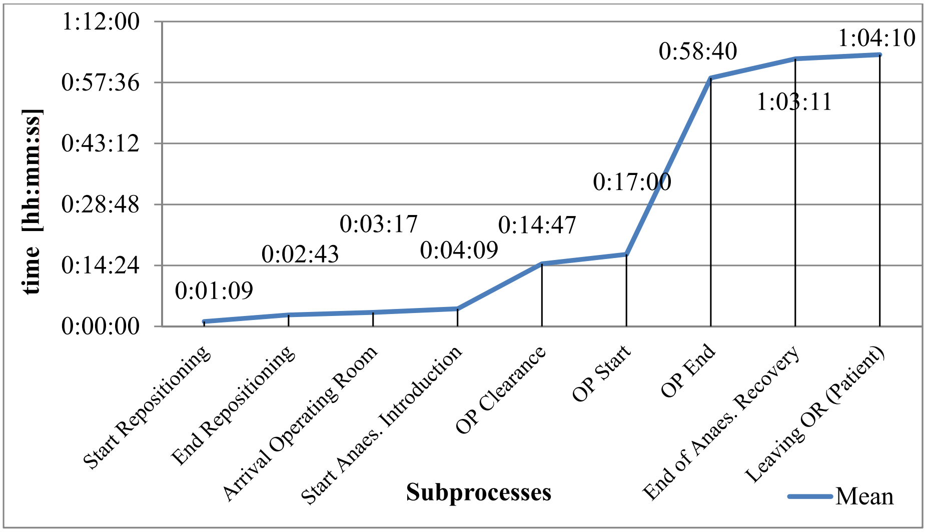

Figure 2. Mean surgical procedure
Source: Own.

Table 1. Perioperative treatment process (I)

	Activity	Mean	Median	SD	Minimum	Maximum
		time value in hh:mm:ss				
OP-Area – Pre Operating Room	Start Repositioning	00:01:09	00:01:02	00:00:52	00:00:00	00:03:30
	End Repositioning	00:02:43	00:02:40	00:01:06	00:00:10	00:05:06
OP Area – Operating Room	Arrival Operating Room	00:03:17	00:03:12	00:01:10	00:00:30	00:05:50
	Start Anaes. Introduction	00:04:09	00:03:25	00:02:25	00:00:30	00:12:54
	OP Clearance	00:14:47	00:13:59	00:05:16	00:03:00	00:48:23
	OP Start	00:17:00	00:16:08	00:05:55	00:05:00	00:49:00
	OP End	00:58:40	00:44:57	00:45:02	00:13:25	04:48:45
	End of Anaes. Recovery	01:03:11	00:52:10	00:47:00	00:12:23	04:56:05
	Leaving OR (Patient)	01:04:10	00:52:20	00:47:10	00:12:48	04:56:30

Source: Own.

Table 2. Perioperative treatment process (II)

	Activity	Mean	Median	SD	Minimum	Maximum
		Single time value (duration of process) in hh:mm:ss				
Pre-OP – Area	Inpatient Admission	00:06:38	00:03:45	00:06:00	00:00:41	00:20:30
	Transportation Ward to Lock System	00:04:56	00:04:20	00:02:32	00:01:09	00:11:14
OP-Area – Post Operating Room	Transportation Operating Room - Repositioning	00:00:54	00:00:29	00:01:09	00:00:05	00:06:16
	Repositioning	00:02:44	00:02:40	00:01:34	00:00:00	00:09:15
	Time in Recovery Room	01:42:09	01:32:28	00:38:55	00:08:03	03:16:28
Post-OP – Area	Transportation Recovery Room to Ward	00:05:28	00:05:11	00:02:43	00:01:30	00:12:56

Source: Own.

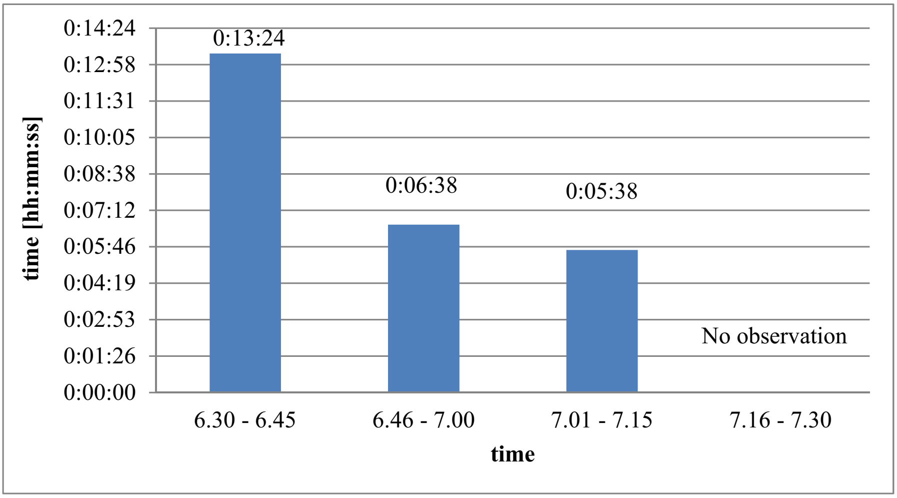

Figure 3. Distribution of average waiting times to be admitted to the inpatient ward
Source: Own.

2.2. Operating-Sector

The interventions were distributed as follows, 67% surgery interventions (SI), 21% gynecological interventions (GYN) and 12% ear, nose and throat interventions (ENT).

According to the objectives of the study the documentation of process delays was important. In the operating-section these delays occurred due to a delayed occupation of the lock system of the operating area, especially in the morning. Despite this disturbance the patient reached the operating room not later than 5min 50sec (on average 3min 17sec; ±1min 10sec) after the arrival at the lock system.

2.2.1. Anaesthesiological Process-Times

Calculating the mean value of the surgery introduction and recovery time the ENT-surgeries were having the highest mean values of those process times (duration of anaesthesiological introduction: 10min 03sec; ±1min 56sec, duration of anaesthesiological recovery: 9min 12sec; ±5min 50sec). Nevertheless, the maximum documented values for ENT-Surgeries (duration of anaesthsiological introduction: 13min, duration of anaesthesiological recovery: 24min) were still below the values for surgical interventions (duration of anaesthsiological introduction: 46min, duration of anaesthesiological recovery: 29min). The average duration of anaesthesiological introduction for gynecological surgeries was 7min11sec. (±2min 26sec). The anaesthesiological processes are shown in *Table 3*.

Table 3. Overview Aneasthesiological Introduction and Recovery

Duration of Anaes. Introduction	Mean	Median	SD	Minimum	Maximum
SI	00:09:31	00:08:45	00:05:38	00:03:16	00:46:51
GYN	00:07:11	00:06:59	00:02:26	00:03:09	00:13:36
ENT	00:10:03	00:09:45	00:01:56	00:06:50	00:13:11
Total	00:09:04	00:08:35	00:04:56	00:03:09	00:46:51
Duration of Anaes. Recovery	Mean	Median	SD	Minimum	Maximum
SI	00:04:49	00:03:18	00:05:13	00:00:21	00:29:42
GYN	00:05:22	00:04:06	00:04:02	00:00:54	00:17:10
ENT	00:09:12	00:07:50	00:05:50	00:02:58	00:24:15
Total	00:05:21	00:03:59	00:05:11	00:00:21	00:29:42

Source: Own.

The mean value of the time period in which the patient is unnecessarily anesthetized (idle anesthesia) was 2min 18sec (±2min 50sec). Therefore, in 86% of all surgeries the patients rest less than 5 minutes in the idle anesthesia and for only 3% of all patients the time period between surgery-clearance and surgery-start was longer than 10 minutes. In 16.4% of the surgeries the missing of an anesthesiologist was documented. The average waiting time for the anesthesiologist was 4min 40sec. Waiting for the senior surgeon was documented in only 3.4% of all surgeries.

2.2.2. OR-Changing-Time

The mean time of the surgical pause in the OR was 48min (±33min 01sec). The average wheel-out-wheel-in time was documented with 28min (±31min 23sec). The relatively high standard deviation occurred due to the high maximum value of 2h 38min (surgical pause). The changing times of all three operating rooms together are presented in *Figure 4*.

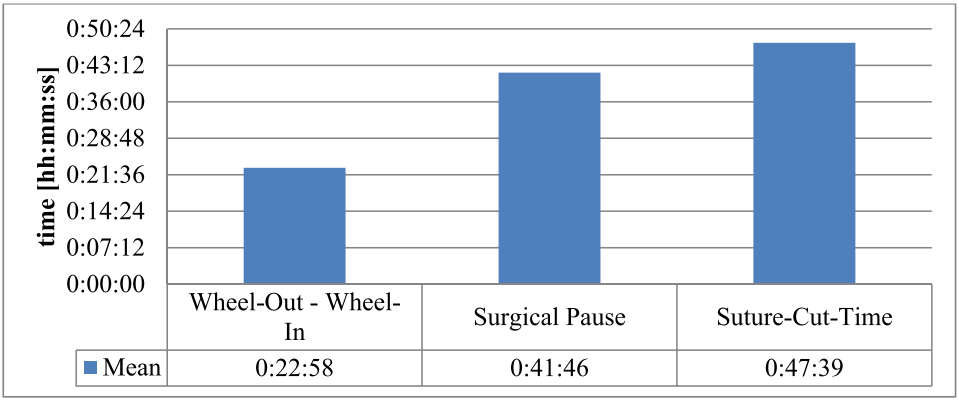

Figure 4. Changing times
Source: Own.

In the morning of a surgery day the changing times (based on the wheel-out – wheel-in) were between 14 and 29 minutes. The analysis of the changing times in the afternoon shows a higher range of the wheel-out-wheel-in time of 45 minutes. In total, only 19.2% of the surgeries were started in the afternoon. *Figure 5* shows the results of the wheel-out-wheel-in time depending on the daytime.

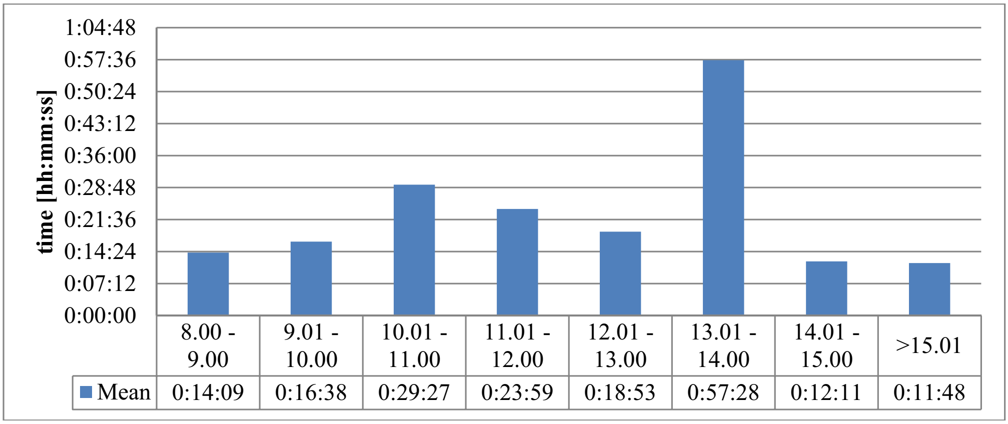

Figure 5. Changing times (wheel-out-wheel-in) depending in the daytime
Source: Own.

2.2.3. Surgery-Planning

In the general hospital the working hours of the OR service started at 6.50 a.m. The first surgery was planned for 8 o'clock a.m. During the time study an average surgical procedure, in which the first patient was transported into the Operating Room at 08.03 a.m., the OP-Clearance was admitted at 08.16 a.m. and the first skin incision was done at 08.23 a.m. (see *Table 4*) could be documented. In 39% of surgeries the first skin incision was done before 08.15 a.m. and in 35% of cases between 08.16 and 08.30 a.m. For the remaining 26% of the patient the first skin incision was done after 08.31 a.m. Assuming that the surgery start and the first skin incision is scheduled for 8 o'clock a.m. a loss of cutting time of 1h09min per day and 5h 44min per week for the three OR was evaluated.

Table 4. Overview Surgery Starting times in the morning

time in hh:mm:ss	Mean	Median	SD	Minimum	Maximum
Patient inside Operating Room	08:03:33	08:00:00	00:11:47	07:51:58	08:39:06
OP-Clearance	08:16:57	08:11:50	00:13:14	08:03:23	08:59:10
OP-Start	08:18:48	08:13:10	00:13:30	08:06:03	09:02:27
Cut	08:23:27	08:20:12	00:14:18	08:07:03	09:02:27

Source: Own.

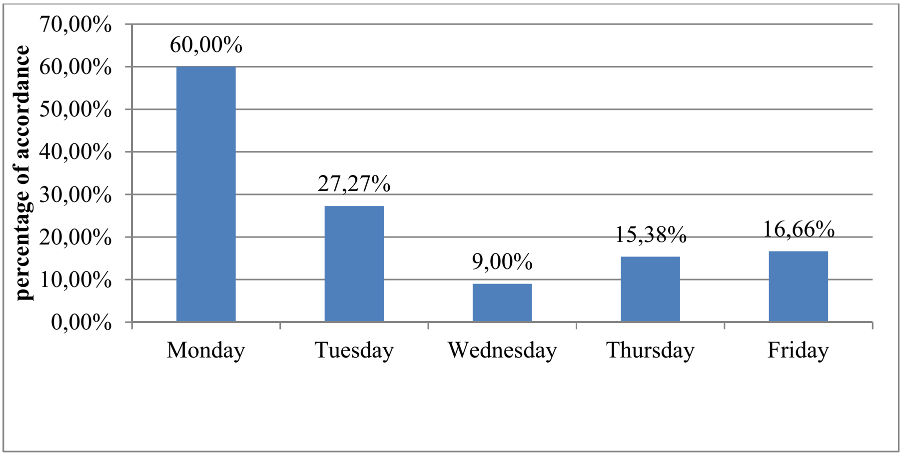

Figure 6. Accordance of the medium- term Surgery Plan and the realized Surgery Plan
Source: Own.

The stability of the surgery planning, which measures the accordance of the short-term surgery plan and the real time of surgeries, reached 78%. In 22% of cases a changing of the short-term plan was determined. The percentage of deviation between the planned time schedules and the real time schedules of surgeries is demonstrated in *Figure 6*.

In addition, in 77% of cases the planned duration of the time-measured surgeries were lower than the real duration and therefore underestimated due to an exceeded schedule. Furthermore, the underestimation was higher, the shorter the duration of the surgery was. While the surgeries of up to 30 minutes were underestimated in 91% of cases, surgeries with a duration between 31 – 60 minutes (61 – 90min) were underestimated in 79% (75%) of cases. An equal distribution of under and overestimation was found for surgeries that were longer than 90 minutes (54% vs. 46%, respectively).

2.3. Post-OP-Section

These process times are presented in *Table 1* and *Table 2*. The time from requesting the transportation until the arrival of the ward´s personnel in the recovery room was on average 2min 11sec (±1min 49sek). The mean process time for the transportation from the recovery room to the ward was 5min 28sec (±2min43).

2.4. Discussion

The main objective of this analysis was to analyze the perioperative processes and to determine potentials for improvement within the perioperative processes.

2.4.1. Pre-operative-section

For the pre-operative-section the average process duration was nearly 7 minutes and delays for patients arose due to a too early arrival before the scheduled appointment. Thus, the level of organization is one of the most important aspects for the pre-operation-section. A highly efficient workflow depends on the level of organization of the wards. A close cooperation between the wards and the operating room is a key figure for an efficient process. Waiting times during the inpatient admission process in the morning mostly occurred due to the situation that the ward´s personnel were involved into other nursing activities. The admission of new patients and the preparation of these patients for the surgeries could not be done immediately. Nevertheless, this did not cause any hindrance in the process flow. However, a more efficient organization could be realized by fixing the arrival time of the patient at the lock of the operating theatre for first surgery of a day and to provide a sufficient availability of an employee at the OR-lock (Busse, 2005).

2.4.2. Comparing Anaesthesiological Processes

Bauer *et al.* measured an average time of 6min for the time period from arriving at the anaesthesiological introduction room until the presence of the anesthesiologist (Bauer, 2004). In our analysis the anesthesiologist started the initialization of the anesthesia on average one minute after the arrival of the patient. This positive value occurred due to the fact that in 84% of all cases the anesthesiologist was already present in the operating room before the patient arrived.

The average anaesthesiological introduction time was 9 minutes. Reasons for the deviating and higher values for the ENT-Interventions were found due to the fact that 71% of the patients were children. Bauer *et al.* revealed an average anaesthesiological introduction time of 22min for general surgery interventions (Bauer, 2004). Considering this, only 2% of the documented anaesthesiological introduction times of this analysis were above the comparative value of Bauer *et al.*

Another positively deviated process value is the idle anesthesia. Comparing this value with the study of Lübbe, in which a mean idle anesthesia of 6min is stated as an in principle acceptable value (Lübbe, 2010), in only 9% of the surgeries the idle anesthesia time of our study was above the comparing value of 6 minutes. The reason for the positive value can be attributed to the missing of waiting times for the surgeon.

Furthermore, the study of Bauer *et al.* presents an anaesthesiological recovery time of 4min (Bauer, 2004). A similar anaesthesiological recovery time was found in our time study (5min). Due to the dependence of the anaesthesilogical recovery time to the health status of the patient, an improvement of the anaesthesiological recovery time is limited.

In the study of Lübbe the duration of the process from the last suture until leaving the operating room was 15min and therefore higher as compared to the time revealed in our analysis (5min) (Lübbe, 2010).

2.4.3. Comparing Surgical Changing Times

One of the major potentials of improvement was the time between the surgeries. The evaluation of the study already presents first ideas for improvement of these changing times. In our process analysis an average surgical pause of 42 min was measured. Despite the documented maximum vacancy of 2h 38min, the surgical pause in our study is still below the value in the study of Bauer *et al.*, who documented an average surgical pause of 43 min (Bauer, 2004). However, Bauer *et al.* analyzed 151 good predictable surgical interventions (Bauer, 2004). The mean surgical pause of the operating room exclusively used for surgical interventions in our study was 5 minutes higher than the value of Bauer *et al.* One possibility for an improvement could be the implementation of a "flying" change through overlapping anaesthesiological introductions. For this purpose the necessary locations and also a team of anesthesiologists would be required. Several studies demonstrated that an overlapping anaesthesiological introduction can lead to a financial success although higher personnel costs occur (Hanss, 2005; Hunziker, 2009; Sandberg, 2005; Torkki, 2005). However, an optimization is still questionable, since the effects of measures are dependent on the supply contract of the hospital and the number of surgeries per day. The coordination and optimization of these changing times is one of the most difficulty tasks for the OP-management. The more the operating plan change during the day, the more difficulties to an efficiently organization of the changing times will arise. Thereby the stability of the OP-planning could be a first major step to improve changing times, reducing vacancies and to avoid an inefficient capacity and resource utilization (Busse, 2009).

2.4.4. Comparing OP-planning

One further major key problem is the delayed beginning of the surgeries in the morning. The main problem in the investigated general hospital was the lack of a definition about the starting time of the surgeries in the morning. A first improvement measure could be to define the starting time and subsequently involve the upstream ward and pre-OP-section stuff, which is responsible for a just in time transportation of the patient to the OR. By using such a scheduling discipline, a timely surgery start in the morning could be provided. This could be shown in several studies (Overdyk, 1998; Truong, 2005). However, this improvement is short-lived and the activity has to be monitored. On the other hand, it should be monitored if a fixed operating schedule fits the morning visits and meetings of the physicians and surgeons.

One main reason for the relatively high changing times around noon (over 57 minutes) was the changing of the surgeons. This could lead to costs of 800 Euro per hour (Baer, 2011). To avoid these, the OP-Management should support the organization of the OP-planning and try to fix the last in house surgery that way, that an efficient transition to an external physician with a hospital affiliation is possible. Urgent or shifted surgeries should try to use variable OR.

The determined OP-planning-stability was 78% and thus, 19% lower compared to the documented OP-planning-stability of 97% in the study of Lübbe. However, Lübbe was solely focusing surgical interventions which can be planned quite good and simple (Lübbe, 2010). Thus, there is only a limited potential of improvement for the hospital evaluated in this presentation. A possible aspect would be to change the short-term OP-plan solely in case of an emergency. Another possibility to improve the procedure could be that patients with a high expected need of preparation before their surgery should not be scheduled at the beginning of an OP-day. Furthermore the OP-plan should be completed and communicated no later than the day before the surgery (Lübbe, 2010). The OP-plan accuracy is characterized in the literature by a systematical underestimating of long surgeries respectively a systematical overestimating of short interventions known as „overconfidence bias“ (Kahnemann, 1982). However, this was not demonstrated in this analysis. Whereas the majority of the measured short-time or moderate-time interventions were mainly underestimated, relatively long surgeries (>90min) were equally over or underestimated.

Conclusion

The basis for a successful OP-management is OP-planning, which is one solution to overcome an inefficient use of the resources available (Wienströer, 2009). By using a purposeful OP-planning method the efficiency of the operating theatre can be increased and costs can be saved. A stable OP-plan, which changes solely in case of unforeseen emergencies, could provide a substantial contribution to increase the economic success and the treatment quality in the surgical area (Fleßa, 2008). By increasing the operating plan stability and accuracy, the vacancy rates and changing times could be substantially reduced. Additionally, an implementing of solid process workflows and standardized rules for interface communication can further improve the operating room organization of a general hospital and thereby increase its profitability and economic success.

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