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ORIGINAL RESEARCH

Evaluation of the Effectiveness of the Separate Anesthesia Induction Rooms on Multidisciplinary Work Flow in Operating Rooms

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Introduction: Operating suites are multidisciplinary units par excellence, and mostly they are the most expensive units in hospitals. Interdisciplinary workflow and efficiency are therefore crucial, which is influenced by floor plans varying from hospital to hospital. Most operating rooms are equipped with adjacent induction rooms, allowing preparation and anesthesia induction of the next patient, while the previous patient is still in the operating room. Parallelizing the working steps is thought to improve turn-over time, thus increasing throughput, number of cases and finally revenue. However, this assumption has never been challenged.

Methods: We analyzed workflow during regular working hours in an operating suite equipped with a mixture of operating rooms (OR) with next door induction rooms and operating rooms without induction rooms. This allows a direct comparison of both structural elements for efficiency using utilization data over a 24-months period. Both settings were used for gynecological operations.

Results: Key result is that induction rooms do not improve perioperative workflow including turn-over time. Instead, ORs without adjacent induction rooms have a significantly shorter turn-over time and OR occupancy duration per case, although surgical time and staffing were similar.

Discussion: Adjacent induction rooms require extra space, funding, and high maintenance costs, but they do not speed up peri-operative processes. Modern anesthetic techniques allow for fast induction of and emergence from anesthesia. Induction rooms adjacent to the OR are no longer needed if general anesthesia without extended monitoring is used for the majority of cases.

Keywords: operating room, efficacy, induction room, turn-over time

Introduction

Operating suites are high cost and high revenue units, with costs generally on the rise and declining reimbursements. Therefore, it is crucial to optimize efficacy of each operating room (OR) while simultaneously minimizing costs, and thus improving revenue.[1]

In this context, reducing idle time is essential in order to process more cases during regular working hours. Most single measures to improve throughput in a given setting, however, save only a few minutes per case, making several measures mandatory, depending on the average time needed per case.[2] Anesthesia induction rooms are supposed to save the most relevant amount of time by parallelizing the entire process of inducing anesthesia, while the OR itself is still blocked by the previous patient, followed by cleaning and the scrub nurses' preparation of all instruments needed for the next case.[3] However, during the last decades, anesthesia techniques have been simplified (eg the widespread use of laryngeal masks instead of endotracheal tubes) and the development of short acting anesthetics helped substantially shorting each patient's wake up time, thus allowing for faster induction of and emergence from anesthesia. We therefore challenged the need for anesthesia induction rooms when we expanded our existing operating suite: Due to limited space,

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we had the option to either add two ORs, each designed with an adjacent room for preoperative induction of anesthesia plus another adjacent room for postoperative emergence from anesthesia, or three ORs with a central holding area equipped with everything needed for induction of anesthesia, or four ORs with a rudimentary holding area, which only serves for having patients from the ward readily available when needed. Although our existing operating suite is designed with an adjacent room for induction of anesthesia plus a room for emergence from anesthesia, we rather decided in favor of more ORs available at the risk of lower effectiveness and lower case load per OR, than having less ORs with the option of better work flow related to adjacent induction rooms.

In the present study, we compare the efficacy of ORs equipped with adjacent induction rooms and emergence from anesthesia, with ORs lacking those extra induction rooms. Both ORs were equally equipped and staffed. Since the effectiveness and the resultant case load per OR may differ between surgical disciplines, we took the chance to retrospectively monitor the performance after our Department of Gynecology had to move from an OR with adjacent induction rooms to an OR without these facilities.

Materials and Methods

Over a period of 24 consecutive months, we looked at the efficiency of our gynecology department by comparing 12 months work flow in an OR equipped with adjacent induction rooms with 12 months work flow in an OR without adjacent induction rooms. Therefore, we retrospectively analyzed the surgical time, OR occupancy time, time for induction of and emergence from anesthesia, and turn-over time (TOT) between cases. The TOT is defined as the entire time between end of surgery (end of wound closure) and begin of the next surgery (next patient's incision) and includes all work steps in-between, such as emergence from anesthesia and patient transport to the recovery room, cleaning of the OR, induction of the next patient's anesthesia, preparing the surgical instruments, disinfection of the surgical area, etc.

In case an OR with adjacent induction room was used, the patient was supervised by an anesthetic nurse preparing the patient for induction of anesthesia, which was then started by the anesthesiologist, while the OR next door still was prepared for the next operation.

All data were retrospectively extracted from our hospital information system (SAP, Walldorf, Germany).

This retrospective study has been exempted from requiring ethical approval by the local ethics committee, since only anonymous data without any reference to patient data were analyzed (Hessian State Medical Association, application number 2022–3122-AF, Frankfurt (FRG), October 5th 2022).

An unpaired Students' *t*-test was used for statistical analysis. Significance was defined as $p<0.05$.

Results

We retrospectively analyzed the time needed to complete different peri-operative work steps over two years, half of the time operating an OR with adjacent induction rooms, the other half working in an OR without induction rooms. A total of 1840 surgical cases were performed during regular working hours by our Department of Gynecology. All cases were included into our analysis.

In both settings, each OR was equally staffed: 1 anesthesiology resident, 1 attending anesthesiologist supervising 8 ORs, 1 anesthesia nurse, 2 scrub nurses, surgeons as needed, and 1 cleaner per 4 ORs.

The duration of all analyzed work steps of the perioperative workflow are summarized in Table 1.

The surgical time of gynecological operations was unchanged, no matter if these operations were performed in an OR with or without adjacent induction rooms. The relatively large variation is due to the broad spectrum of gynecological operations, ranging from a 3-minute hysteroscopy to a 10-hour cancer-related laparotomy.

Interestingly, induction of anesthesia and emergence from anesthesia took significantly less time when performed in the OR itself instead of being performed in separate induction rooms, leading to a significant reduction of TOT by 13 minutes per case on average.

The early morning start of the first surgical case was significantly improved when anesthesia was introduced in the OR itself. Also, the number of cases started in time, which is before 08:05 a.m. in our institution, were higher in the OR without adjacent induction rooms (101 versus 51 per year).

Table 1 Duration of Analyzed Perioperative Work Steps

	OR with Adjacent Induction Rooms	OR without Adjacent Induction Rooms
Start first surgery	08:12 a.m. ± 17 Min	08:07 a.m. ± 16 Min*
Induction of anesthesia	16 ± 11 Min	11 ± 9 Min*
Emergence from anesthesia	13 ± 10 Min	10 ± 7 Min*
Surgical time	55 ± 59 Min	50 ± 58 Min
OR occupation	84 ± 71 Min	76 ± 70 Min*
Turn-over time	49 ± 19 Min	36 ± 22 Min*

Notes: Mean ± SD; *p<0.05.

Discussion

There exists a wide variety of different floor plans in operating suites, depending on the age of the facilities and the surgical disciplines using it. They mostly consist of ORs with adjacent rooms for induction of and emergence from anesthesia. The OR's design is supposed to have a substantial impact on surgical workflow.[4–6] Being one of the most expensive units in terms of building-costs, running costs and staff salaries, each hospital's administration has a special focus on the effectiveness of these units. However, studies analyzing the impact of architecture and/or changes in workflow are only available as mathematical models.[7] Until now, for example, there is no data available comparing the impact of extra induction rooms on operating suite efficiency. This is even more amazing, since these extra rooms require rare and expensive extra space. Furthermore, these induction rooms also need to be fully staffed with expensive medical equipment, such as oxygen and vacuum lines, ventilators and monitors. In order to reimburse this investment, throughput of these ORs should be significantly higher when compared to ORs lacking these extra rooms. In recent years, central holding areas with the ability to induce anesthesia were implemented in newly built operating suites to replace the induction rooms for each OR. However, even this new concept has never been analyzed or challenged before, thus looking more like a bad compromise than a safe and sound concept, neither economically, nor from the medical point of view.

Nonetheless, most of newly built operating suites are still based on classic floor plans with ORs, each being equipped with adjacent induction rooms, or at least having implemented a central-holding area as described above. We show that parallelizing anesthesia work steps, the scrub nurses' preparation and clean-up can easily be integrated into the OR itself. We further paralleled, wherever medically reasonable, the patient's instrumentation with arterial and central venous lines, while the surgeons simultaneously started to disinfect the surgical area and subsequently started the operation itself. However, in our setting, any regional blocks or regional catheters needed for postoperative pain-control were introduced pre- or postoperatively in the recovery room, no matter whether the patient was operated in an OR with or without adjacent induction room. Our nursing staff in the recovery room has been trained to assist with these blocks.[8]

Paralleled peri-operative work steps are supposed to minimize the TOT between operations. Relocating anesthesia work steps into different rooms or into a holding area is thought to speed up the peri-operative process, because anesthesia no longer interferes with other peri-operative work steps, eg scrub nurses' preparation of surgical instruments. However, the time needed for induction of and emergence from anesthesia only contributes to a little more than half of the TOT. Also, these anesthesia procedures can easily be paralleled in the OR itself.

In our study, mean surgical time and surgical spectrum (gynecology) were comparable in both settings studied. Since the entire staffing remained unchanged, differences in the duration of other peri-operative work steps are solely related to the availability or lack of adjacent induction rooms.

Comparing the duration of different work steps, the presence of adjacent induction rooms in our study had no positive effect on work flow and did not increase the OR's case load. Different than expected, having work steps paralleled in the OR itself because of a lack of adjacent induction rooms did not prolong TOT. Instead, TOT was significantly reduced,

since induction of and emergence from anesthesia took less time when performed in the OR. Interestingly, even the OR occupancy was significantly lower in the OR without adjacent induction rooms, although in this setting, induction of and emergence from anesthesia is performed in the OR itself, thus contributing to the OR occupancy. But obviously, other work steps before and after surgery take more time than induction of and emergence from anesthesia. First and foremost, the preoperative preparation of all surgical instruments plus handing over all disposable items needed as well as the postoperative instrument's processing and clean-up should be named here.

The reduction of time needed for induction of and emergence from anesthesia, the reduced OR occupancy per case and the reduced TOT most likely were rendered possible by the fact, that the different players of the OR team (scrub nurses, anaesthetic staff, surgeons) watch each others progress and keep pushing and adapting their peri-operative workflow case by case, consciously or unconsciously. This also holds true for the early morning start of the first case, which was significantly earlier in the OR without adjacent induction rooms (08:07 versus 08:12). Accordingly, days with a surgical start on time were doubled.

The interference cannot only be observed between anesthesiologist, scrub nurses and surgeons: Interestingly, the time available for cleaning was halved in the stand-alone OR compared to the OR with adjacent induction rooms, although the cleaning procedure remained unchanged. Since our study was retrospective and thus free of any bias, we cannot identify the underlying cause. However, knowing anesthesia to be performed next door rather than having the anesthetist waiting to enter the OR for preparing next cases' anesthesia may have taken pressure from the cleaning staff.

Both, the significantly earlier start in the morning, plus the significantly reduced TOT sum up to a time saving, which allows for scheduling additional cases per day and OR, thus improving revenues.

It is important to note that patient safety was never compromised: In each individual case, there was a brief pause to go through the surgical safety checklist in the presence of the entire team, including surgeon and anesthesiologist.[9]

Our study shows for the first time that adjacent induction rooms had no positive impact on peri-operative work flow. Instead, we demonstrated even a slight but significant reduction in TOT, while the mean surgical time showed no difference.

Building extra induction rooms for induction of and emergence from anesthesia for the purpose of maximizing each OR's case load seems to be a useless investment. Building an additional OR at the expense of lacking induction rooms is the better investment.

Limitations

In this study, we focussed on gynecological operations. Extra induction rooms may be beneficial in surgical disciplines requiring complex anesthetic catheterization prior to surgery, such as pediatric cardiac surgery. However, extra staff is needed to allow for induction and catheterization of the next patient, while the previous patient is still in progress. This may or may not have an impact on improved turn-over-times. However, operations requiring complex anesthetic preparation are mostly associated with long surgical time, and the time saved by overlapping the next case does not allow to schedule an extra case of that complexity.

Theoretically, extra-anesthesia personnel may have helped to improve the extra induction room's impact on TOT. However, the additional salaries need to be reimbursed by improved TOT. In our study, the TOT in the OR with adjacent induction rooms was 20 minutes longer than the entire time spent in the induction room, indicating that anesthesia is not the limiting factor. Thus, extra-anesthesia personnel would have not improved TOT. Further, the stand-alone OR delivered improved TOT and shortened OR occupancy despite the fact that all anesthesia procedures were to be performed in the OR itself, again proving anesthesia not to be time limiting.

Conclusion

The present data shows that the availability of an anesthesia induction room does not necessarily result in better turn-over performance in the adjacent operating room. Building extra induction rooms for induction of and emergence from anesthesia for the purpose of maximizing each OR's case load seems to be a useless investment. Building an additional OR at the expense of lacking induction rooms may be the better investment.

Abbreviations

OR, operating room; TOT, turn-over time.

Data Sharing Statement

All data are on file with the corresponding author. They are available on request.

Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Disclosure

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