

# Smart operating room and surgery driven by artificial intelligence

Artykuł recenzowany/Reviewed article

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## Abstract

*From a surgical point of view, artificial intelligence (AI) does seem to be the holy grail of future medicine. Today data driven medicine influence also handwork - done with knives, scissors, needles and sutures. Should a surgeon learn something about AI and data science? Big data, machine learning, NLP, video analysis and robotics will be a big part of modern surgery. Today's operating robots like the Davinci already works with video analysis and machine learning. How AI will influence the OR of the future will be shown in this story. Please meet Dr. Smith. The surged of the future!*

### Słowa kluczowe:

*sztuczna inteligencja, zarządzanie szpitalem,  
zarządzanie oddziałem chirurgicznym,  
sala operacyjna*

### Keywords:

*artificial intelligence, hospital management,  
management of the surgical department,  
operating room*

## INTRODUCTION

To open some more minds about AI, we want to show a different perspective and introduce some thoughts about the future operation theatre and surgical patient management. Therefore, let us introduce Dr. Peter Smith, a general and visceral surgeon in our future hospital. During ward run in the morning, he notices that his patient is already on the way to the operating room. After a short time, Dr. Smith's smartphone is vibrating. He is called to come to the OR, his patient is ready for surgery. In between, he checks all significant lab values, images and medical information about the patient on his mobile device prepared by new Hospital-AI-Software. Arriving the operation theatre, Dr. Smith is automatically recognized as the primary surgeon by FCS (face recognition system). Entering the room he is introduced with the words: "Good morning Dr. Peter Smith, the

patient Anna Hanson is ready for the cholecystectomy. The personal patient identification is completed, all instruments ready, navigation online, devices checked, the whole team is ready to start." Dr. Peter Smith is concluding "Thank you, Team-Time-Out complete, operation will start:" As the operation goes on, a voice appears with the question, whether the next patient can be called for transportation to the operating room. Dr. Smith confirms this recommendation. After finishing, Dr. Smith heads to the documentation area. After entering to a computer terminal, all significant information about the operation is already documented. He just has to check the data and answered the questions according eventual irregularities. All information is automatically stored in a database. At that time, the patient after cholecystectomy is already on his way to the recovery unit and the next patient is clear for operation.

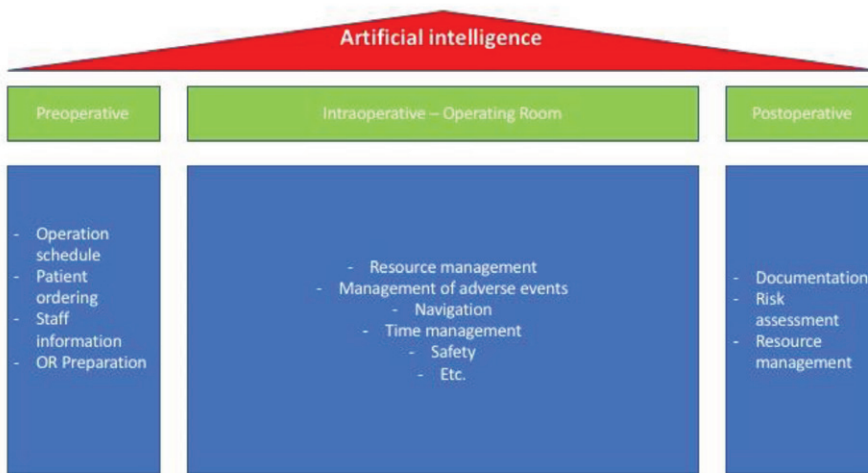


Figure 1. Artificial intelligence in perioperative setting

Now, the question is: Where is the place of AI in this scenario? We would like to present our imagination about AI in a peri-, intra- and postoperative setting (Figure 1) dealing with these major topics: time and resource management, workflow, safety, documentation data collection and prediction.

**■ TIME AND RESOURCE MANAGEMENT**

In our daily work, operating room schedule is set by preoperative study of images and medical information of the patients. And of course, by the experience of the planning surgeon. This often leads to the fact that planned procedures have to be shifted to the next day due to unexpected events or misplanning, with consequences with discomfort of patients and additional costs for the hospital. Dr. Smith’s experience will be different. His patient was already on his way to the operating room. An AI, which knows diagnosis, planned procedure, medical data, number of staff for the day, surgeon and other information, planned the schedule, even the transport was organised and performed by robots. Based on this data, time and length of the operation is already predicted and the operation theatre is optimal selected, so that there is no delay and interference with other operations. Like in modern automotive industry, where all parts are delivered to the production line “just in time”, patient, nurses, anesthesiologist and instruments are called to proceed to their dedicated places. And of course, the workflow of our Dr. Smith is managed. He is called via smartphone, where all information about the patient and the time schedule are listed. Dr. Smith confirms the call and heads to his operation.

After a while, the smart operating room asks Dr. Smith for confirmation if the next patient can be ordered. If he confirms the recommendation the next patient will be on his way. In case Dr. Smith does not

confirm the next available surgeon will be called to overtake the responsibility and “keep the workflow going”.

This is possible because significant steps of the operation are captured by the AI and the end of the operation can be predicted. The system consists of many robots, engines, sensors and cameras who are cooperating with each other and will be able to optimize and improve the process itself in the future. So the next patient is chosen automatically based by diagnosis, planned operation, team, next free theatre, etc. On the end the time and resources are optimally used.

**■ SAFETY**

During the evolution of surgery and surgical devices, patient’s safety plays a major role of development of procedures as well as hospital structures. After implementation of “Surgery Safety Checklists” by WHO and Team-Time-Outs before starting surgery, patient’s safety was increased and the number of mistaken patient identity was decreased dramatically (Renner et al., *Deutsch Arztebl* 2012; 109(20): A 1016–8). As you remember our Dr. Smith enters the OR, was welcomed with his name, the procedure he is going to perform and of course the patient’s name. This is because the smart OR has recognized the patient by reading an individualized digital wristband. AI knows the diagnosis, the actual continuous vital parameters, actual location and the procedure planned for this patient even better as the surgeon. The latter is recognized by his smartphone and is confirmed by voice of face recognition system, automatically. By these facts, all identification data is double checked in addition to the Team-Time-Out.

All instruments and devices are delivered to the OR just in time. AI knows about the comorbidities of the patient and calculates the risk of adverse events.

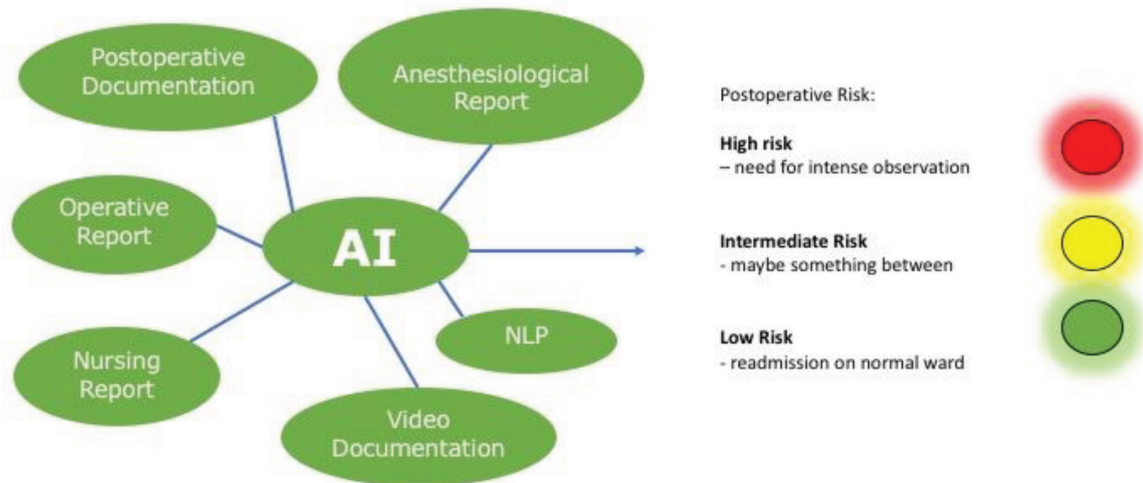


Figure 2. Different data assessed during operation and in the postoperative phase. This can be used for postoperative risk assessment

Based on this risk, AI has automatically provided additional monitoring devices, additional instruments and special anesthesiologic medication by the OR-Supply-Robot. If it is needed during the procedure, the whole team can draw on these things rapidly. During the laparoscopic cholecystectomy which is performed by Dr. Smith, a augmented reality visualization system enhances critical structures on the screen. Every step is observed by the AI. This machine learning based supervision detects adverse events. If for example a significant bleeding is detected, the surgeon is asked to confirm that everything is all right. If he does not react, an automatic call for the next free surgeon is sent to obtain help. This minimizes time to react on difficult events and decreases the risk of life-threatening conditions. After surgery, all data collected during the operation, for example blood pressure, heart rate, ventilation parameters, lab values and given medication, accompanied by detection of adverse events, blood loss, etc. is stored and analysed by another machine learning. A risk-score is calculated to help distinguish that either an intensive care unit treatment, or an intermediate care bed is needed for the patient (Figure 2). In our case, everything is clear, double controlled and the patient can proceed via recovery room to normal ward. As we all know, intensive and intermediate care beds are rare. It should be mentioned that in this particular area we would find incredible potential for saving costs using AI. Generally the system will help to ensure that critical patients are triaged to the optimal level of care.

**DOCUMENTATION:**

Surgical documentation plays a crucial role. It is important for communication between health care professionals, planning future operations, research,

education and of course legal issues. Written documentation is often incomplete, especially after long procedures, or when documentation is done hours or days after the operation and always slow. AI can help thought automatically report and produce significant improved value.

After finishing the operation, Dr. Smith enters the a computer terminal. After recognition of Dr. Smith's smartphone all significant stored data of the past operation are shown on the screen. Crucial steps of the procedure are stored as short video clips. The AI previously selects different issues and the surgeon just have to pick the ones he needs. AI provides postoperative care planes according to analyzing comparable operations and the actual patient condition. Not only obvious information is stored. Additionally the number of towels, sutures, needles and the overall used equipment is analyzed. Furthermore, utilization time or used energy of coagulation device, other power ran equipment, used medication and the vital signs of the patient during operation influence a score, calculated by AI to distinguish postoperative level of care (as explained above). The documentation gains quality, simultaneously improves management and care.

**DATA COLLECTION:**

Surgery is producing a great amount of data. Generally, there are various data during an operation. Sometimes it is so obvious, that we see and hear it all day, but do not think of using it! For example, our verbal and non-verbal speech. Natural language processing helps detecting words and sentences. This can be analyzed and lead to special reactions. The word "bleeding" for example can activate a cascade of happenings such as call for further medical support and additional resources. Different devices

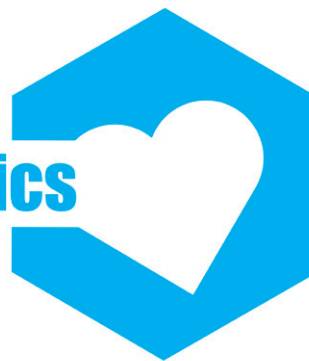
produce various noises. For example the “beep” of the coagulation device indicates its use. On the other hand noise level inside the operating room can denote stress. As in our example, time of procedure can help to plan and manage operation schedule. Vital signs, medication, ventilation parameters and blood loss can be used for calculating risk scores. All consumable material can indicate any adverse events occurred during operation, but is not analyzed in real time nowadays. Imagine videos in HD or 4K of all operations during the day. The amount of data the surgical OR could producing per day is not comparable with any other medical profession. The Big Data is there - We just have to use it.

■ **CONCLUSION:**

Artificial intelligence is probably one of the most interesting area of science, today. It changes our daily life although we often do not even recognize it. Therefore, Data and data science is one of the most promising fields in modern medicine. Subfields such as pathology, radiology and dermatology already use machine learning based tools for diagnostics. Nowadays, Electrocardiograms are analyzed in real-time. The question is, how can artificial intelligence influence and improve a surgeon’s life? As we showed in our example with Dr. Smith, there are several points of AI’s contacts in a surgeons daily work. Big Data and AI will highly influence the decision making and can help by real-time data analysing in the future. OR data is generated continuously, but we have to make this data usable. Future medicine is AI based medicine!

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