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Ergonomic Aspects of Transport of Patient through the Operating Theatre

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Abstract. One of the most crucial decisions to be made while designing and re-modernizing an operating theatre is selecting a method of transporting the patient through the hospital's spatial arrangement. This decision, while irrelevant at first thought, implies numerous project and functional consequences.
Designing an operating theatre within a hospital is related to numerous specialist requirements with an aim of minimizing the risk of microbiological contamination. Surgeries conducted on the operating theatre take place within sterile areas, usually within a protection area provided with laminar air flow. Furthermore, currently in Poland, there are applicable rules requiring to have entrances secured with tract locks leading towards the operational rooms for hospital personnel, patients as well as hospital equipment and materials. Such construction of an operating theatre provides the necessity of applying detailed procedures of transporting the patient, who in most cases is not able to reach the surgery on his or her own.
In operating theatres functioning during the last decades, the operating tables were most often fixed to the floor. This resulted in the need to relocate the patient, who is ready for surgery, for several times. The consequences of this included risks related shock due to the relocations for the patient as well as physical overload for the medical staff.
The aim of hereby article is to present modern designer solutions providing the opportunity to enhance ergonomics of using the operating theatre.

1. Introduction

The operating block is a separate unit within the spatial arrangement of a hospital or clinic with the capability to provide surgical services within the span of one day. Architectural solutions for operating blocks are adapted to its working technology, including also solutions associated with medical equipment, as well as sanitary and hygienic requirements. The increased risk of hospital infection at the place of surgical procedure performance results in the development of stricter sanitary requirements for operating blocks. The resulting requirements regarding a correctly functioning unit clearly indicate the necessity for control and separation of the flow paths of patients, personnel, equipment and medication delivered to the operating room, as well as disposal of used, post-surgery materials. These restrictions also apply to the possibility of introducing equipment for patient transportation into areas with an increased level of sanitary requirements. The entirety of guidelines used for the operating block make it one of the most difficult to design spaces within a hospital [1].

This article attempts to present spatial solutions for the operating block, which incorporate various types of medical equipment solutions for the purpose of providing the most optimal method of delivering

patients to the operating table and safely transporting them away to the patient care room following surgical intervention.

2. Patient transport within a hospital

Relocation of a patient in a condition which makes it impossible for them to move on their own is a very complex procedure. This subject has been tackled by a variety of studies, whose purpose was a safe flow of patients within individual units of a medical centre [2-13]. In accordance with the current state of research, we distinguish three primary types of patient transport depending on the spatial scope in which relocation associated with provision of medical services takes place:

- Intra-hospital transport – transport of a patient within one medical centre between different residential, diagnostic and surgical wards.
- Inter-hospital transport – transit of a patient from one medical unit to another located outside the specific building complex.
- Emergency transport – transport of a patient from outside the medical environment, e.g. from their place of residence or the site of an accident to a hospital or clinic.

Medical transport in all cases is associated with threats to the patient's condition as a result of relocation and the risk of complications associated with occupational diseases in the case of attending personnel. Incorrectly performed patient transport on a transport cart or bed may cause impairment of the patient's health. The critical moment is the patient's transfer, for example, from the hospital bed or operating table onto a transport cart. Relocation may be a source of additional complications. The risks related to patient transport from room to room within one facility or to another medical centre are especially high in the case of patients in a critical condition or post-surgery, sensitive to displacement and shock. Studies carried out at the turn of the 1960's and 70's have shown that Intra-hospital transport of patients with advanced heart conditions may result in arrhythmia (84% among the persons analysed). Additionally, in the studied group as many as 44% of patient's required emergency rescue following the performance of relocation [3]. Later analyses conducted by teams of experts on various groups of patients have confirmed the occurrence of risks to the patients' health as a result of intra-hospital transport. Implementation of organizational improvements results in the degree of risk being lowered, yet still remaining at a level which requires medical personnel to consider the benefits arising from the performance of examinations or procedures in a different location over the risk of complications caused by destabilising the patient [4-8].

The second significant negative result of patient relocations performed within a hospital complex is the gradual activation of occupational diseases amongst medical personnel. The consequence of manual transfer of a patient from the hospital bed onto a transport cart (and vice versa) is the necessity to carry out work associated with subsequent patient transfers, which is strenuous physical work. Lifting and moving the patient are actions performed multiple times in a lowered upper body position, which does not allow for the use of leg muscle strength, and the patient's weight places the load primarily on the lower back muscles. As a result, some nurses who deal with medical transport complain about pain of the lumbosacral section and the cervical section of the spine. According to studies conducted in 2003 on a group of 230 nurses working in four hospitals in Poznań, 73.23% of survey respondents suffered pain in the joints and (or) spine. Over half of the respondents (55.86%) associate their pain ailments with lifting heavy loads [9]. In the most unfavourable case, namely in the situation of a functional operating block with a permanently installed operating table, with transport carts traveling within the confines of the block and with limited mobility hospital beds and the resulting necessity to use hospital transport carts, there is a requirement to transfer the patient six times within the operating block and twice in the patient's room.

Transfer of a patient at the operating block:

1. Patient airlock at the operating block – patient transfer from the hospital transport cart to the operating block transport cart;

2. Operating room prior to surgery – patient transfer from the operating block transport cart onto the operating table;
3. Operating room post-surgery - patient transfer from the operating table onto the operating block transport cart,
4. Recovery room - patient transfer from the operating block transport cart onto the intensive care bed;
5. Recovery room - patient transfer from the intensive care bed onto the hospital transport cart;
6. Patient airlock – patient transfer from the block transport cart onto the patient's bed or the hospital transport cart.

Such a number of patient transfers means that attending four surgery procedures performed on patients with an average weight of 80 kg, hospital personnel must daily lift an approximate total of two tons (4x6x80 kg = 1920 kg). Complications increase with the appearance of persons suffering from pathological obesity, whose weight exceeds 200 kg. Bariatric patients constitute a group which requires verification of undertaken organizational procedures and the necessity of assisting personnel with mechanical equipment [10]. The most frequently occurring ailments among medical personnel involved in patient transport within an operating block and the intensive care wards include: straining of the spine, back and neck, as well as hand and arm joints. Additionally, the patient transfer procedure constitutes a source of frequent workplace accidents, such as slipping or stumbling, which may cause serious injury or constitute a risk to the patient being tended to [11].

Most guidelines in place to prevent or minimise the risks arising from transport concentrate on organisational development of procedures, individual personnel preparation and technical assistance in the form of medical equipment [12-13]. Rarely in this case is an analysis of the hospital's layout and medical technology taken into consideration. An example of the possibilities of different patient transport solutions within an operating block indicates the validity of approaching the topic also from an architectural perspective.

3. Patient transport systems within the operating block

An example of an operating block's spatial layout makes it possible to showcase the correlations between architectural solutions and the patient transport method in the context of planning procedures for reducing the negative consequences of hospital transport. One of the primary decisions which must be made when designing an operating block is one associated with selecting the means of patient transport within the hospital infrastructure. Adopting a specific solution is results in a range of limitations associated with the high sanitary requirements set for operating rooms, as well as the previously mentioned risk of impairing the patient's condition or the threat of medical personnel suffering from occupational illness syndromes.

The types of models for patient transport onto the operating block, the flow within its area and the means of transporting the post-surgery patient beyond the operating block may be distinguished based on currently available medical equipment technologies. The three models discussed are based on differences in relations between the functional system applied and the medical equipment selected for it:

1. An operating room equipped with an operating table permanently installed into the floor, with patient transport being carried out using a transport cart.
2. An operating room equipped with a mobile operating table which moves within the operating block.
3. An operating room equipped with an operating table with mobile slabs, which are transferred onto transport carts which move within the operating block and outside of it.

Figure 1. Patient transport carts

The first model discussed deals with the largest number of patient transfers carried out by the medical personnel. Entry of a hospital bed into the operating block area is impossible due to the risk of transferring pathogens from the hospital environment to the area subject to the highest level of epidemiological protection. The adoption of restrictions to the entry of external means of transport to the operating block results in the necessity of patient transfer. The patient is transferred in an airlock onto a means of transport functioning within the operating block. Further transfers are generated by the immobile operating table type and the location of the recovery room. This transport model is presented in figure no. 4.

Figure 2. Mobile operating table

In the second model the operating block is equipped with mobile operating tables. (Figure 2) These allow to limit the number of patient transfers thanks to their transport capabilities. They do, however, have a significant disadvantage associated with their structure. An example weight of such a mobile operating table is approximately 280 kg. With the additional weight of the patient, the equipment becomes difficult to manoeuver – even with mechanical assistance, which requires battery power. An unquestionable advantage is the possibility of eliminating patient transfers in the operating room and limiting or completely eliminating the use of patient transport carts within the operating block.

Figure 3. Mechanical equipment supporting patient transfer

The third model assumes the use of mobile operating table slabs. A stable column is permanently installed in the operating room. A slab is placed on top of it, which is transported in together with a patient on the transport cart. This facilitates transport within the operating block and the weight of the transport unit is reduced compared to the second model by the weight of the operating column. In order to eliminate manual patient transfers in the operating block it is possible to use mechanical equipment supporting patient transfer. (Figure 3) A huge aid in this procedure is the use of a stationary transfer unit which enables the transfer of a patient within the hospital. The use of such a device must, however, be planned at the early stage of planning the operating block. This is a result of equipment installation and spatial requirements.

From an architectural perspective, another significant element assumed in a model which limits the number of patient transfers is the recovery room location. Finding an optimal location for it within the hospital's functional structure is associated with the need to consider a range of architectural conditions, including those related to communication with the operating block, as well as the bed ward. The recovery room's location within the operating block makes it possible to reduce the patient transport time to the operating room in the event of post-surgery complications. This, however, generates the requirement of two additional patient transfers. The assumption is, that a recovery room located outside the operating block area makes it possible to reduce the number of patient transfers, which limits the associated risks, but may simultaneously result in extending the time needed to return to the operating block in the event of complications. In the discussed operating block spatial layout model, the recovery room is located outside its area, but directly adjacent to it. This makes it possible for the patient to relatively quickly return to the operating room and limits the number of patient transfers. This transport model is presented in figure no. 5.

4. Conclusions

The issue of patient transport within the operating block is an example of how far the technology of carrying out medical procedures influences the spatial layout of the hospital building. Before making a decision to modernise a medical centre or designing a new unit it is necessary to adopt certain technological and architectural assumptions. Of utmost importance is the ability to consider ergonomic conditions in the design of medical facilities, which in turn influence the spatial solutions.

Dynamic changes to the technological conditions in healthcare facility design result in the need to implement changes within medical buildings based on expert surveys conducted on a regular basis, taking into consideration the medical, economic and ergonomic context. This is facilitated by a search for optimal solutions for medical centres, supported by results of scientific studies. In accordance with the method of Evidence-Based Design popularised for over a decade in Europe, the architect's techniques increasingly often incorporate scientific analyses regarding contemporary needs of healthcare facilities in practice [14].

In the article, the above correlations have been discussed on the example of an operation block patient transport system based on changes to the functional equipment and architectural arrangement of rooms. Such a change would eliminate the need for manual patient transfers within the operating block, but would also result in a change to the functional arrangement of the operating block. As presented in this article, systems are currently being developed to enable the elimination of manual transfers within the operating block, however, their correct implementation in the case of existing facilities requires thorough intervention in the existing operating blocks' constructive tissue. Due to the risks of injury to the patient as well as personnel presented in the article, it is necessary to implement systems limiting patient transfers based on most recent architectural and ergonomic studies, which would make it possible to create an optimal design solution for a given medical facility.

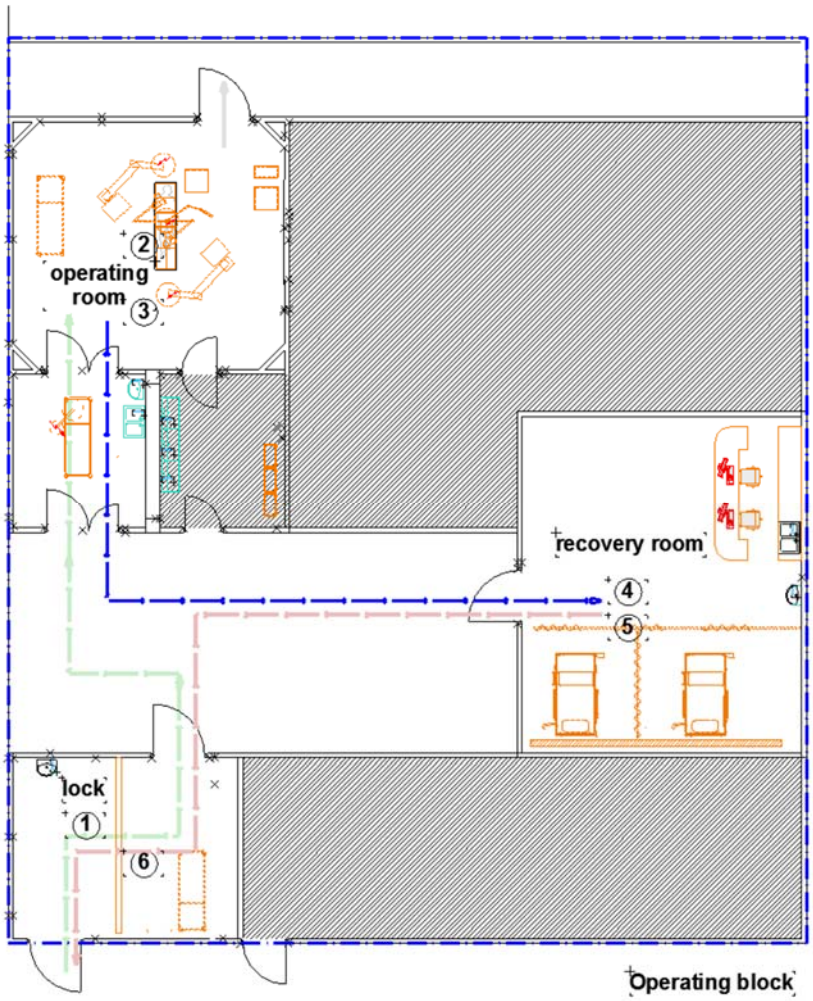

Figure 4. Patient transport plan in the first model

1 Transfer in the patient airlock room onto the block transport cart
2 Transfer from the block transport cart onto the operating table
3 Transfer from the operating table onto the block transport cart
4 Transfer from the transport cart onto the recovery room bed
5 Transfer from the recovery room bed onto the block transport cart
6 Transfer in the patient airlock room from the block transport cart onto, for example, the patient's bed.

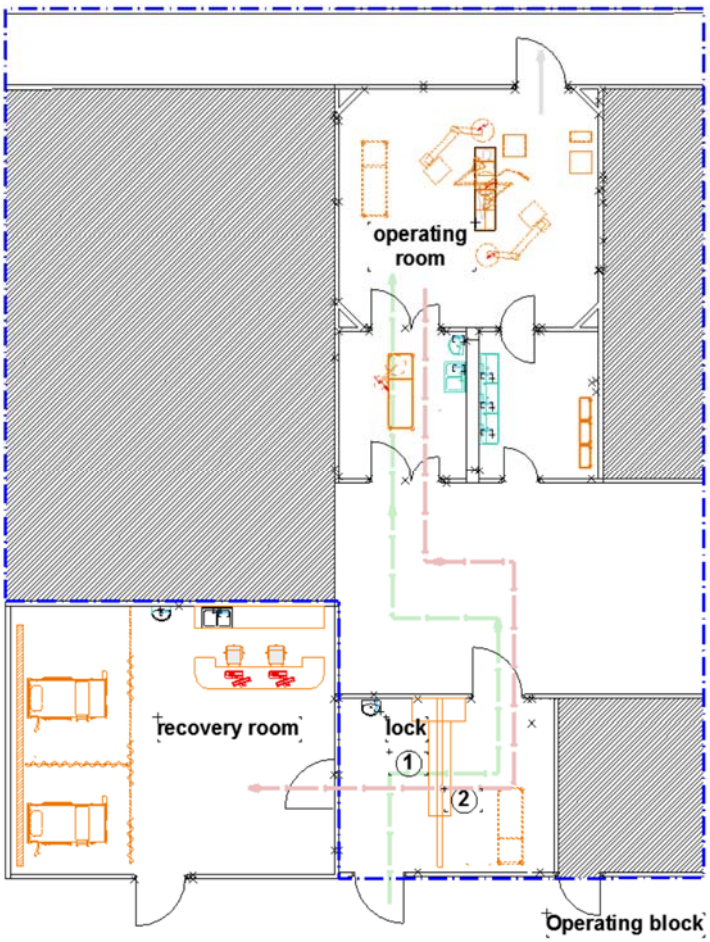

Figure 5. Patient transport plan in the third model

1 Transfer using stationary patient transfer equipment in the patient airlock room onto the operating slab
2 Stationary patient transfer equipment in the patient airlock room from the operating slab onto the patient's bed

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