

AFROS 2018, A HVNS algorithm for solving multistage operating room scheduling integrating building surgical team constraints

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Abstract

The management of operating theaters is currently the subject of numerous questions, both in the short term and the long term. It is hampered by the difficult employment problems of both human and material resources, which are now both available in finite capacity. The surgical process, normally consisting of preoperative stage, operative stage and postoperative stage, represents a composite universe in which a multitude of different professions and facilities are expressed, the purpose of which should be the same: patient care. Firstly, an adapted Variable Neighborhood Search algorithm (VNS) was proposed to solve our Operating Room Scheduling Problem (ORSP). Secondly, a Hybrid Variable Neighborhood Search approach (HVNS) was also generated for its resolution. The comparison results show the superior performance of the (HVNS) approach terms of the optimization criterion makespan. They further prove the advantages of the variable neighborhood search metaheuristic to solve a complete three-stage surgery-scheduling problem taking into consideration the building surgical team constraints.

1 Introduction

The operating room department is one of the most costly and important areas in the hospital. It is a highly strategic location for the technical platform because it involves almost activities of the sectors component of this technical platform. These sectors include surgery, obstetrics, anesthesia, resuscitation, functional explorations and interventional disciplines, radiology and, biology (Revel et al., 2003).

The optimization of its functioning is thus one of the first concerns of both the managers and the actors operating there. This department is also the most complex ward to manage and to plan, since it includes a large number and variety types of equipment in addition to the difficulty to standardize and coordinate surgery cases. In order to show the interaction of the operating room ward with the rest of the hospital departments, we present the different phases of the surgical process. The latter can be broken down into three main phases:

- The pre-operative phase extends from the surgery decision for the patient until his transfer to the operating room. During this phase, the patient undergoes surgical and anesthetic consultations and a provisional intervention date is proposed to the patient. This date can be modified according to the operating room policy.
- The per-operative phase corresponds to the patient's stay in the operating room (OR). This phase is the most important activity in the surgical process.

- The post-operative phase: the patient is transferred either to the Post-Anesthesia Care Unit (PACU) or to the Intensive Care Unit (ICU) if his condition presents complications. This phase covers all necessary care following the surgery.

According to the description of the surgical process, it can be seen that the operating room also represents an interface between several other areas of the hospital, such as hospitalization and recovery services. The required resources to perform a surgery consist of human resources such as nurses, anesthetists and surgeons and, facilities such as PHU beds, multiple (ORs), and PACU beds or ICU beds.

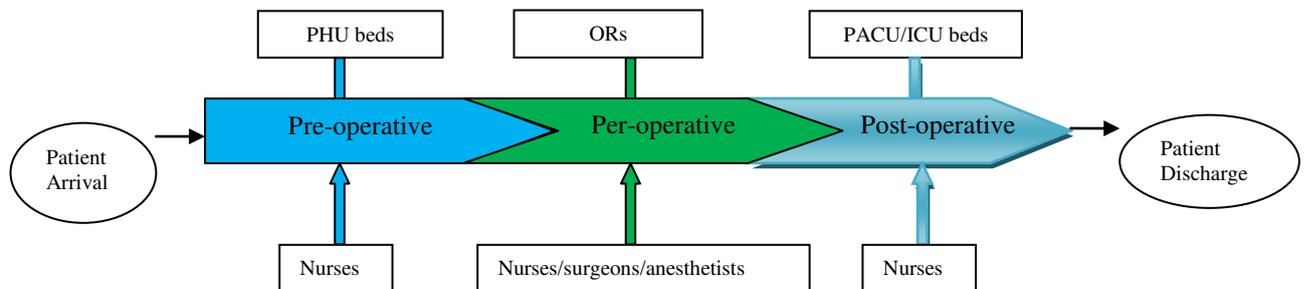


Fig.1. Overall surgery process

The study of **Weibroum et al. (2003)** determined that PHU, PACU and, ICU present 32% of the inactivity-time cause in the overall surgical process respectively 17% in PHU and 15% between PACU and ICU. This result explained the need to consider activities upstream and downstream of the per-operative phase in the global optimization of the OR department. In this research, we make this process more efficient and productive by integrating the upstream and the downstream phases in the ORSP.

Moreover, Mazzocco (2009) and Weaver (2010) studied communication, coordination and cooperation and showed that any conflict within a team had a negative impact on patient safety. It is, therefore, essential to try to establish good agreement within the surgical teams. Let us take as an example the Belgian university hospital of Antwerp (UZ Antwerpen), which aspires to qualify as a “Magnet hospital”. The concept of a “Magnet hospital” is of American origin and associates quality of care and staff satisfaction, postulating that both go together. UZ Antwerpen set up group activities outside the institution (running, fitness...) to stimulate a team spirit (K. Mortelmans, 2010). We, therefore, took into account the affinity existing among members of the surgical staff

The ORSP consists in organizing over a time horizon the realization of a set of surgeries, taking into account temporal, use and, availability constraints of the required resources. Different criteria for ORSP are presented in the literature either related to time such as completion time, waiting times, different delays or advances against the set deadlines. Other criteria related to the cost including overtime and rate of resource utilization. The completion time is usually the main criterion in scheduling problems. Our studied problem aims to minimize the makespan optimization criterion and other performance evaluation criteria such as overtime, OR variation coefficient of working time and CPU time.

This article consists of seven sections: in the second section, we present a review concerning ORSP. An ORSP is introduced in the third section. In the fourth section, a model description and notations are presented followed by an outline of VNS algorithm and HVNS approach. In the fifth section, experimental results are analyzed. Finally, conclusions and perspectives are presented in section 7.