AFROS 2018, **An improved tabu search algorithm for surgery scheduling problem with maximal time lags**

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Abstract

Operating theater is considered as the most expensive health department within hospital centers due to its significant services for patients and to its economical benefits for the hospital. Scheduling defines the final step of the operating room management process. The problem turns out to be more difficult when various surgical specialties are considered in the models beside a wide range of available resources for the three surgical stages. As a result, heuristics or meta-heuristic methodologies are frequently developed to efficiently tackle this NP-hard problem.

In this paper, we have firstly introduced an optimization model that captures a wide range of real world elective operational Surgery Scheduling Problems (SSP) with no-wait constraint between surgery stages. Then in the second part, we consider time lags constraint in the model to show its effects to the schedules. We propose an improved Tabu Search (TS) metaheuristic which includes an appropriate neighborhood search procedure and some adjustments of the various parameters. Computational experiments used a set from literature. The experimental results show the effectiveness of the proposed algorithms in terms of makespan, overtime, variation of working time coefficient and computing time. They also prove that the generated schedules by consideration of the time lags present better performance in the most studied cases.

1. Introduction

The sector of health care is continually evolving. In this specific circumstance, the hospital supervisors need to make their business more beneficial. They try to improve the performance of their organization through benefit improvement and patient satisfaction while depending on given defined resources. The functioning of this department is commonly a very difficult task due to the existence of some limitations such as the lack of specialized surgeons and equipment, long waiting patient list and shortage of beds.

Managing the operating theater consists in planning and scheduling the cases to be operated (Zhou, Yih, & Lu, 2016). Actually, the planning stage decides when the patient will be operated while considering the existence of free operating rooms and the required surgeons. Making a daily schedule defines the sequence of the patients to be operated in every room by assigning the required

resources to their surgeries. Even though they are interrelated, these two sub-problems are generally separately treated.

The surgical process of a patient is divided into three stages: pre-operative, per-operative and post-operative. The preoperative phase corresponds to the management of the patient until the day before surgery, to do consultations and examinations. The per-operative phase defines the surgery duration that takes place in the operating room. The postoperative phase covers all the care following the surgery. During the preoperative phase after the surgical and anesthetic consultations, a date of hospitalization must be proposed to the patient, taking into account his availability, the availability of the surgeon, the possibilities of the operating room as well as the hospitalization service like availability of post-operative care beds. In the per-operative phase the decisions to be taken relate to the operational organization of the operating theater. Staff must be present in sufficient numbers when an operating room is opened to form the required team. Surgeries must be assigned to an operating room and ordered by the operating room so that the required logistics (stretcher-bearers, sterile medical devices, etc.) around the operating room are available in the appropriate place at the suitable time and for the right patient.

In fact, a surgical procedure consists in carrying out various activities in the operating theater. Generally, these activities are conducted in a precise order and then are organized in three inter-related stages involving the pre-operative, operative and post-operative stages. Generally the required resources to achieve these activities are surgical equipment (surgeons, anesthetists and nurses), facilities especially Pre-operative Holding Units (PHUs), Operating Rooms (ORs) and Post-Anesthesia Care Units (PACUs) or Intensive Care Units (ICUs).

Several research studies emphasized the scheduling problem in operating rooms only. Nevertheless, a few researchers dealt with the planning problem inside PHU, PACU and/or ICU as a complete stage of service.

Weinbroum, Ekstein, and Ezri (2003) analyzed the cause of OR idle time during the stages of surgery: 17% in PHU, 15% in PACU or ICU, 30% in nurse shortage, 10% in surgeon unavailability and 3% in transport. This research showed that it is necessary to take into account all resources required by the overall surgical process to improve the utilization of operating theatre facilities. The integration can also be reinforced by the ICU rejection rate, which can go up to 24% for elective cases (Kim, & Horowitz, 2002). A scheduled elective case can be rejected on its surgery day due to the shortage of PACU/ICU beds. So the lack of coordination with PACU/ICU may minimize the utilization rate of OR and has negative impact on the patient satisfaction. In addition, allowing to patient waking up in ORs increases the rotation time between surgeries, overtime and surgery cancellations. We can conclude therefore that there is a close relationship between all the stages of the operative surgery. As a consequence, only by including the whole OR suite facilities in global model we can achieve optimization.

The rest of the paper is sorted out in the following way. In section 2, we quote the latest research on SSP. Section 3 presents a mathematical model for the SSP and a study of its complexity. The proposed approach for optimization of the SSP is introduced in section 4. Illustrative test cases are reported in section 5. Numerical results generated by both TS algorithm are interpreted in section 6. SSP with maximal time-lags constraint is presented and discussed in section 7. Conclusions and future research are presented in section 8.