

Scheduling Strategies for Operating Room Surgical Scheduling Problems

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Abstract

Optimizing surgical scheduling problem (SSP) plays a crucial role in improving hospital health care services. Many studies tackled this problem with different perspectives, i.e. different solution approaches, decision levels, mathematical models and scheduling strategies. Thus, this work aims to review some literature in SSP that focused on scheduling strategies: open strategy, block strategy and modified block strategy. We discuss the strength and limitation of these scheduling strategies and pointed out the practicality of these strategies in real hospital practice. We also identified some approaches proposed in the literature related to each of these strategies. The study shows that block strategy is widely used in real life though it has some limitations, such as underutilization which can be tackled by applying modified block strategy. We also addressed that among several solution approaches, metaheuristics are frequently applied while considering different scheduling strategies.

Keywords: Surgical scheduling; Operating room; Scheduling strategy;

1. Introduction

In recent years, the operating room plays a crucial role in health care, and the demand for quality service is increasing day by day. The operating room is the core sector for both cost and revenue in a hospital (May et al, 2011). It is reported that more than 60% of patients are admitted for surgical operation, and undoubtedly, it is a very complex task to be tackled by the hospital management (Fügener et al, 2017). The surgical scheduling problem (SSP) is a complex problem because it involves many resources and stages. Many works tackled this problem from different perspectives, such as solution approaches, decision levels, mathematical models and scheduling strategies. The targets of hospital managers are to maximize the utilization of operating room and this leads to different strategic plans (Gür & Eren, 2018). Thus, in this work, we focus on the view of scheduling strategies. Scheduling strategies can be grouped into three strategies: open strategy, block strategy and modified block strategy.

Block Scheduling Strategy: A scheduling strategy is called block strategy when each operating room is pre-allocated to a speciality with different surgery groups such as surgeons (Zhu et al, 2019). Each operating room can be divided into different time slots for different speciality, or can be allocated with a speciality for the whole day (Zhu et al, 2019). In block scheduling, some human resources such as nurses and anesthesiologist are assigned to each block, which is applicable for a cyclic timetable such as a certain number of weeks or months (Rahimi & Gandomi, 2020). This strategy can be classified into two types such as block strategy with master surgical scheduling and block strategy without master surgical scheduling (Gür & Eren, 2018).

Open Scheduling Strategy: This strategy is the opposite of the block scheduling strategy. There is no pre-allocation of any operating room. Surgery case can be assigned to any operating room regardless of the type (Agnētis et al, 2014). If the number of required resources is available, the surgery can be performed in any suitable operating room. Most of the time, open strategy follows First-Come-First-Serve principle (Zhu et al, 2019). Patients are scheduled without any speciality related restriction (Augusto et al, 2010). While assigning patients to operating room, it is not necessary to check the speciality of the operating room. Any patient can be assigned to any available operating room.

Modified Block Scheduling Strategy: This is the combination of block and open strategy to use the advantages of both strategies. There are two ways to modify block strategy and apply it as modified block strategy (Fei et al, 2009). The first one is to reserve some operating room and to keep open for others. The second way is to release unused blocks for the remaining surgeries.

2. Advantage and disadvantage of different scheduling strategies

Each scheduling strategy has its advantages and disadvantages. Table 1 shows the comparison of these scheduling strategies.

Table 1. Advantages and disadvantages of different scheduling strategy

Strategy	Advantage	Disadvantage
Block Strategy	<ul style="list-style-type: none"> - In real life, block scheduling strategy is applied more often in many hospitals because the complexity of this strategy is lower than open strategy (Zhu et al, 2019). - Surgeons' preference is to centralize all the surgeries at a specific time of workday. So, applying this strategy is suitable for surgeons because working time is fixed in this strategy (Zhu et al, 2019). - This strategy reduces the time required for preparation and cleaning time between surgeries which also reduces the patient waiting time (Gür & Eren, 2018). 	<ul style="list-style-type: none"> - In this strategy, the operating room is allocated to some specific surgeon, and if there is no surgical case for that surgeon on the day or the cancellation occurs, other surgeons cannot be assigned to that time block/operating room.
Open Strategy	<ul style="list-style-type: none"> - It is a more flexible strategy because there is no pre-allocated time block. - With the comparison of block scheduling strategy, the open strategy has better utilization of operating room (Zhu et al, 2019). 	<ul style="list-style-type: none"> - A bad design of open system can cause a high loss rate. - This strategy is not popular in real life because it causes inconvenience, and also surgeons cannot centralize their work. - May have to face inconvenience when they have to deal with emergency cases because patients have priority to choose time (Zhu et al, 2019). - This strategy may cause long waiting time because of dynamic patient arrival (Zhu et al, 2019).
Modified Block Strategy	<ul style="list-style-type: none"> - This strategy is more convenient for operation room management because it can assign other operations to perform in the operation room to prevent the loss of late cancellations (Agnētis et al, 2014). - Capable to solve the problems mentioned for block and open strategy. 	<ul style="list-style-type: none"> - No disadvantage reported in the literature.

Although there are some limitations, block strategy is applied in many hospitals, for example, many hospitals in Europe adopt this strategy (Penn et al, 2017). In many hospitals, the block strategy is implemented due to surgeons' preferences (Zhu et al, 2019). Open strategy is flexible but may cause low utilization or delay. For all these reasons, open strategy is not mostly adopted in real life because this strategy is not popular among surgeons (Zhu et al, 2019). Many studies reported on block and open scheduling strategy but modified block scheduling got least attention to study although it can be the solution of the limitations mentioned above. So here is an opportunity to investigate in future about modified block scheduling strategy.

3. Methods

There are many studies reported on different surgical strategy. Table-2 represents some studies on different scheduling strategy and methods used to solve the SSP in between the year 2016-2020.

Table 2. Studies on different scheduling strategies and their solving approaches

Paper	Block Strategy	Open Strategy	Modified Block Strategy	Solution Approach
Zhang et al. (2020)	✓			Column-generation-based heuristic
Khalfalli et al (2020)		✓		Adaptive Tabu Search
Zhu et al (2020)	✓			Hybrid Grey Wolf Optimizer - Variable Neighbourhood Search
Behmanesh et al (2019)		✓		Fuzzy Pareto envelope-based selection ant system
Lin & Chou (2019)		✓		Hybrid genetic algorithm
Khalfalli et al (2019)		✓		Tabu search
Moosavi et al (2018)	✓			MIP-based Local Search Neighborhood
Wu et al (2018)		✓		Hybrid genetic algorithm -variable neighborhood search
Nyman & Ripon (2018)		✓		Simulated Annealing, Genetic algorithm, Variable neighbourhood descent
Xiang (2017)		✓		Ant Colony Optimization
Guido & Conforti (2017)	✓			Hybrid genetic algorithm
Mateus et al (2017)	✓			Local search heuristics
Beroule et al (2016)		✓		Particle Swarm Optimization
Marchesi et al (2016)	✓			Genetic algorithm
Doulabi et al (2016)		✓		Branch-and-price-and-cut algorithm

Here, we took randomly three studies for five different years and tried to compare which scheduling strategy studied more on SSP. Table-2 represents that, in between the year 2016-2020, most of the studies are focused on open scheduling strategy and some are focused on block scheduling strategy. However, no studies are reported on modified block scheduling strategy. Table-2 also shows that metaheuristics such as tabu search, genetic algorithm, simulated annealing, particle swarm optimization etc. are mostly applied for solving both strategies. Other than the mention studies, (Liu et al, 2010) considered both open and block scheduling strategies and solved by heuristic approach. Although by applying modified block scheduling strategy, the drawbacks of other two strategies can be overcome, it is not studied enough.

4. Conclusion

Many works are done so far with different scheduling strategies but number of studies differs from year to year. For example, until 2010 block strategy got more attention. But now most of the studies focus on open scheduling. On the other hand, there is very few studies on modified block scheduling strategy. In real life block strategy is more preferable because human resources of surgery can centralize their work but still there is some limitations in this strategy. To overcome the problems of block strategy, modified block strategy can be applied which is also preferable for the management.

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