Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Pediatric surgical wait priority score (pSWAPS): Modifying a health system's adult-based elective surgery prioritization system for children's surgery during the COVID-19 pandemic

Bethany J. Slater a,∗, Michael T. Cappello b, Mark M. Butterly c, Jonathan Sherman d

a Department of Surgery, University of Chicago Medicine and Biological Sciences, 5841 S. Maryland Avenue, Chicago, IL 60637, United States
b Advocate Children’s Hospital, Park Ridge, IL, United States
c Advocate Children’s Hospital, Oak Lawn, IL, United States
d Department of Surgery, Advocate Children’s Hospital, Oak Lawn, IL, United States

A R T I C L E   I N F O

Article history:
Received 16 July 2020
Revised 7 December 2020
Accepted 12 December 2020

Keywords:
COVID-19
Elective surgery
Pediatric SWAPS
Scoring system

A B S T R A C T

Background: With the rise of COVID-19 cases, societies recommended canceling all elective surgical procedures because of perioperative concerns, transmission risk, and the need to divert resources. Once the number of cases stabilized, there was recognition that a system was needed to triage and prioritize scheduling operations.

Methods: A universal scoring system to triage surgical elective cases was developed for the Advocate Aurora Health system (Surgical Wait Priority Score, SWAPS) and was modified for use in pediatrics (pSWAPS). Resource-related, patient-related, and case urgency factors were used to create the overall score. Interrater reliability of ten cases was determined by four surgeons’ scores and calculating Fleiss’ Kappa coefficient. The system has been used for two months at two operating rooms with different resource restrictions with the goal of prioritizing elective cases.

Results: 18 factors were identified as significant contributors to the pSWAPS creating a cumulative score ranging from 0 to 120. In the first month, 61 and 99 procedures were screened at the Oak Lawn (OL) and Park Ridge (PR) campuses respectively, and in the second month, 94 (OL) and 135 (PR) procedures were evaluated. The average pSWAPS scores were 37.9 at OL and 54.3 at PR. All cases that had scores within the immediate group were scheduled and completed.

Conclusion: The pSWAPS system is a simple, flexible scoring system that takes into consideration resource constraints. pSWAPS has been used for two months. It has served as an effective tool for safe and methodical reintroduction of elective procedures during the COVID-19 pandemic and could be used again for another surge.

Level of evidence: prognostic study, level of evidence - 4.

© 2020 Elsevier Inc. All rights reserved.

1. Introduction

In late December, reports of a novel coronavirus SARS-cov-2, or COVID-19, leading to a severe respiratory distress syndrome began to emerge from China and then quickly expanded to the United States. By March, the number of cases escalated exponentially, and the outbreak was classified as a pandemic by the WHO [1]. The main focus of healthcare systems centered on delivery of care to cohorted intensive care patients with COVID-19 as well as the safeguarding of adequate personal protective equipment (PPE) and ventilators. Due in part to hospital systems being overwhelmed and scarcity of resources, the American College of Surgeons and other professional societies recommended canceling all elective cases in mid-March [2]. The rationale for stopping elective cases was because of perioperative concerns [3,4], the risk of transmission to the operating room staff, and the need to divert resources to treat COVID-19 patients (personnel, intensive care beds, PPE, testing materials). A number of adult studies reported significant postoperative morbidity, especially pulmonary complications, and mortality in patients with COVID-19 undergoing surgical procedures. It is unknown if the same risks pertain to the pediatric population given the lack of data. The Advocate Aurora Health system followed these recommendations and halted all nonemergent operations at the hospitals.

Once the number COVID-19 cases began to stabilize, there was recognition that a system needed to be developed to triage and prioritize scheduling of operations once it was felt safe to restart performing “elective” surgical procedures. Our hospital system developed a framework to prioritize surgical operative cases tak-
ing into account the hospital resource utilization, the COVID-19 transmission risk, and the type and acuity of the procedure. The main considerations for procedure acuity involved deliberation of whether postponement of surgery would potentially threaten life, limb, or development, lead to progression of disease, or increase the risk of complications, such as infection.

Thus, the goal was to initiate elective surgery by implementing a simple triage system. In this way, a structure was put in place to determine groups of cases that qualify for either immediate scheduling, future scheduling, or does not qualify for scheduling. There have been proposed scoring systems that have recently been published for both adults and pediatrics [5,6]. Our hospital developed an alternative scoring system that was adapted for use in pediatric surgical cases and used in a hospital system of Children’s Hospitals within Adult Hospitals.

2. Methods

A universal scoring system to triage surgical cases during the COVID-19 pandemic was developed for the larger Advocate Aurora Health system, Surgical Wait Priority Score (SWAPS), and this was modified for use in pediatrics at the Advocate Children’s Hospital sites (pSWAPS, Fig. 1).

A fundamental premise of the scoring system was that all cases considered “emergent” or “essential” by the surgeon were to be scheduled at the site directly, without a pSWAPS score, and that those cases were to be prioritized with a separate set of resources. pSWAPS scores were used for elective cases only. Emergent surgery was defined as any case for which any delay risks life or tissue loss. Essential surgery was defined in our system as any case that was not emergent but in which delay of greater than a week was very likely to have a negative impact on patient outcome.

Advocate Children’s Hospital has two campuses, each of which physically exists within a larger medical center that also cares for adult patients. Because of the relationship between the Children’s Hospital site and its related adult medical center, the basic adult scoring system was maintained so that children could be scored alongside adult patients. Therefore, each child’s overall pSWAPS score was based on the same three subscores used to create the overall adult SWAPS score: resource-related factors, patient-related factors, and case urgency. Also, each overall pSWAPS score used the same 0–120 point scale, as was used in adult patients. The major adaptation made to the adult system for scoring in children (aside from the specific diseases considered in the patient-related score) was the weighting of these three categories. In the Children’s hospitals, there were open beds on the floor and ICU and greater pediatric staff available throughout the pandemic, and so the weight given to the resource related factors was lowered. In pediatric patients, the effect of COVID-19 infection on surgical outcome and health in general is less clearly established, and so the patient-related factors were also deemphasized. The effect was that the overall score was weighted more strongly on the case urgency, as determined by the surgeon.

2.1. Resource-related factors

During the COVID-19 pandemic, a fundamental consideration in delaying elective procedures is to preserve resources so that they are available for COVID-19 infected patients during a surge. Some of those resources - personal protective equipment, uninfected staff, operating rooms, other hospital inpatient space and resources - are shared by the entire larger healthcare system, and more intimately by each Children’s Hospital site and its related adult medical center.

In the adult SWAPS, resource-related factors constituted one third of the overall score, and these factors were further subdivided into Operating Room (OR) resources and perioperative resources. The OR resources (OR staff, operating rooms, PPE) were a shared resource between children and adult patients. The perioperative resources were largely separate (ICU patients were housed in a separate ICU, floor patients had separate pediatric floor beds, and pediatric negative pressure space in the hospital was separate from adult negative pressure space). The Illinois Department of Public Health (IDPH) mandated in a state-wide communication that 20% of perioperative resources (medical/surgical beds, ventilators, and ICU beds) be available prior to elective cases being completed in each adult hospital [7]. In children’s hospitals, however, these perioperative resources were not required by the
Table 1
Inter-rater reliability assessment using the pSWAPS system. To validate the pSWAPS system, 10 elective cases were described with brief clinical vignettes and then scored by 4 independent surgeons. The resulting scores, shown above, were used to determine inter-rater reliability by calculating Fleiss’ Kappa. There was strong agreement among independent surgeons in determining that a case did not qualify for scheduling, but less strong agreement among surgeons in determining if a case qualified for immediate or future scheduling, I = Immediate, F = Future, N = not qualified.

| Surgeon: | Example 1 | Example 2 | Example 3 |
|----------|------------|------------|------------|
| Patient: |            |            |            |
| Surgical Case: |            |            |            |
| A. Pediatric Resource/Procedure Factors | | | |
| Intra-Operative Variables: | | | |
| Incision-Closure >120 | 0 | 0 | 1 |
| LOS > 24 hrs | 0 | 1 | 1 |
| OR staff > 2 | 0 | 1 | 1 |
| Total Score | 0 | 2 | 3 |
| Risk Stratification | Low | Medium | High |
| Peri-Operative Variables: | | | |
| General anesth | 0 | 1 | 1 |
| ICU Stay post op | 0 | 1 | 1 |
| Abd-pelvic/Thoracic/Upper GI/Head and Neck | 0 | 0 | 1 |
| Covid+/Sx’s/Known Exposure W/I 14 days | 0 | 0 | 1 |
| Total Score | 0 | 2 | 4 |
| Risk Stratification | Low | Medium | High |
| Total Resource/Procedure Factors | 0 | 4 | 7 |
| A. Resource/Procedure Score | 0 | 10 | 20 |
| B. Pediatric Risk/Patient Factors | | | |
| Anesthesia Variables | | | |
| age < 6 mos | 0 | 1 | 1 |
| chronic lung disease/ pulmonary hypertension | 0 | 1 | 1 |
| DM | 0 | 0 | 1 |
| congenital heart disease | 0 | 0 | 1 |
| immunocompromised | 0 | 0 | 1 |
| Total Score | 0 | 2 | 5 |
| Risk Stratification | Low | Medium | High |
| Pulmonary/Covid Variables | | | |
| OSA / CPAP | 0 | 1 | 1 |
| Asthma/ Congenital Emphysema | 0 | 1 | 1 |
| Home O2 | 0 | 0 | 1 |
| Covid+/Sx’s/Known Exposure W/I 14 days | 0 | 0 | 1 |
| PE/DVT within 12 months | 0 | 0 | 1 |
| Total Score | 0 | 2 | 5 |
| Risk Stratification | Low | Medium | High |
| Total Risk/Patient Factors | 0 | 4 | 10 |
| B. Risk/Patient Factor Score | 0 | 10 | 20 |
| C. Pediatric Priority/Case Factors | | | |
| Impact of > 4week delay on disease/procedure | | | |
| Low - No Worse | high | | |
| Medium - Moderately Worse | medium | | |
| High - Significantly Worse | low | | |
| C. Priority/Case Score | 0 | 40 | 80 |
| Total Risk Stratification Score(A + B + C) | 0 | 60 | 120 |
| Status: Qualifies for immediate scheduling date | Qualifies for future scheduling date | Does NOT Qualify for scheduling | |

IDPH. Therefore, we decided to use the same set of adult SWAPS variables for the pSWAPS, but to decrease the overall weight of the resource-related factors in the overall score (from 33.3% to 16.7%).

In calculating the resource subscore, a single point was given for each of the following resources: time greater than 120 min, length of stay greater than 24 h, OR staff greater than 2 people, general anesthesia, ICU bed needed, aerosolizing procedure, COVID positivity or exposure / negative pressure room requirement. Resource subscores of 0 were assigned a weight of 0 in the overall pSWAPS score; subscores of 1–4 were assigned a weight of 10 in the overall pSWAPS score; and subscores 5–7 were assigned a weight of 20 in the overall pSWAPS score.

2.2. Patient related factors

Comorbid conditions, including COVID-19 infection, affect surgical outcome. If a patient was expected to do poorly in and after surgery (and ultimately require greater hospital resources), that patient’s case was given lower priority. Therefore, the next section of the adult SWAPS score was determined by patient-related comorbidities. In the development of the corresponding pSWAPS score, pediatric-specific analogous conditions were used. Age less than 6 months, chronic lung disease, diabetes mellitus, congenital heart disease, difficult airway, and an immunocompromised state were considered anesthesia-risk factors; and CPAP use, asthma, home oxygen use, COVID-19 exposure, and DVT/PE history were considered COVID-19 specific variables that would potentially further complicate outcome if the child were to become infected. Because the association between these comorbidities and poor surgical outcomes in children is less clear than in adults [8], the patient-related factors were weighted less in the overall score for children (from 33.3% to 16.7%).

In calculating the patient subscore, a single point was given for each of the following conditions: age less than 6 months, chronic lung disease, diabetes, congenital heart disease, immunocompromised state, CPAP use, asthma, home oxygen, COVID positivity or exposure, DVT/PE. Patient subscores of 0–2 were assigned a weight of 0 in the overall pSWAPS score; subscores of 3–4 were assigned a weight of 10 in the overall pSWAPS score; and subscores 5 or greater were assigned a weight of 20 in the overall pSWAPS score.
2.3. Case urgency/disease-related factors

The dominant factor in the determination of the pSWAPS score was the case urgency. This was determined by the surgeon and was a judgment on the risk presented by delaying the case. The overall weight of the case urgency subscore was 66.7% in the pSWAPS scoring system, which was double that of the adult system. The result was that all pediatric cases for which an impact of delay was low received high overall pSWAPS scores and were not candidates for scheduling. This was fundamentally different from the adult scoring system, in which a patient with low impact of delay would be scheduled if the resource- and patient-related factors were favorable. Conversely, pediatric patients with the highest risk of harm from delay would be scheduled regardless of the other subscores, while adults with highest risk of harm from delay would only be scheduled if the resource- and patient-related factors were favorable.

To calculate the case urgency subscore, the surgeon or proxy was asked to simply predict the impact of delay of 4 weeks. If the impact of delay of greater than four weeks was high, a score of 0 was assigned for the case urgency sub-score. If the impact of a four week delay was considered moderate, a score of 40 was assigned. If the impact of a four week delay was considered low, a score of 80 was given.

2.4. Overall pSWAPS determination

The overall pSWAPS score for each case was determined by adding the resource-, patient-, and case urgency subscores, resulting in an overall score between 0 and 120. Initially, overall scores of 0–20 were considered for immediate scheduling. Initially, overall scores of 30–60 were considered for future scheduling (placed onto the schedule but not preferentially in the first 4 weeks). Cases with pSWAPS scores greater than 70 were not scored initially if there were significant resource restraints. As resources became more available during the pandemic, cases with higher scores were considered for scheduling. Each operating room site considered the number of available rooms each week to determine what the cut-off scores would be for scheduling.

2.5. Determining the validity and interrater reliability of the pSWAPS score

Because of the significant risk of subjectivity that was introduced by weighting urgency highly, interrater reliability was determined and all submitted scores were subject to review by a committee of physicians.

To determine interrater reliability, pSWAPS scores were determined by four independent providers of a single surgical specialty...
for each of ten actual surgical patients whose case was delayed by COVID-19 restrictions using brief clinical vignettes. Fleiss' Kappa coefficient was calculated, using the nominal outcomes of “qualifies for immediate scheduling,” “qualifies for future scheduling,” and “does not qualify for scheduling.” The case vignettes are presented in Table 2.

To ensure that scores were being appropriately assigned on an ongoing basis, a committee of surgeons, hospitalists, and intensivists reviewed the cases for approval biweekly after the pSWAPS form had been submitted, as directed by the IDPH. The system has been used for approximately two months since the reactivation of elective surgical cases.

3. Results

18 factors were identified as significant contributors to the pSWAPS scoring system creating a cumulative score ranging from 0 to 120, with the most urgent cases receiving the lowest score. These factors were created by a working group of surgeons, anesthesiologists, nurses, and leadership members. In the first month of reactivation (05/03/20–06/03/20), 61 and 99 elective procedures were evaluated using the scoring system at the Oak Lawn (OL) and Park Ridge (PR) campuses respectively, and in the second month (06/04/20–06/24/20), 94 (OL) and 135 (PR) procedures were evaluated. The total number of pediatric cases done during these times were 85 and 250 at OL and 229 and 195 at PR (Fig. 2, Table 3). The average SWAPS scores were 37.9 at OL and 54.3 at PR. The average pSWAPS scores increased from 30.4 to 42.4 in OL and from 38.2 to 70.4 in PR. No patients that were screened and had a score within the immediate group had their operations deferred. In addition, no urgent operative intervention because of deferment of an elective operation occurred during this timeframe.

During the first and second months of reactivation in OL, 181 and 393 procedures were completed on adults. During the first and second months of reactivation in PR, 517 and 715 procedures were completed on adults. Thus, the fraction of cases that were completed on children rose from 14% to 27% in OL and 15% to 19% in PR when comparing the 12 months prior to the pandemic to the early reactivation phase.

To determine interrater reliability, ten cases were reviewed by four separate children’s surgeons and scored using the pSWAPS system. Results are shown in Table 1. Fleiss’ Kappa was calculated. \( K_i \) (for immediate scheduling) was 0.278 \( (p = 0.03) \); \( K_f \) (for future scheduling) was 0.528 \( (p = 0.01) \).
scheduling) was 0.231 \((p = 0.07)\); and \(K_{N}\) (for not qualified) was 0.739 \((p = 1.06E-08)\). Fleiss’ Kappa was calculated to determine the interrater reliability using four independent raters. Fleiss’ K values of 0.21–0.4 are generally considered “fair agreement.” \(K_{N}\) (for not qualified) was 0.739 \((p = 1.06E-08)\). K values of 0.6–0.8 are generally considered “substantial agreement.”[9]

4. Discussion

We have described a scoring system for elective surgical procedures that incorporates the hospital resources and limitations as well as patient and surgical factors. The system can be adjusted depending on resource utilization requirements. The scoring system is not meant to be a detailed ranking method, but instead to serve as a decision-making tool to group the procedures into categories of immediate scheduling, future scheduling, and not qualified for scheduling, taking a number of factors into account. In this manner, it simplifies the difficult task of determining which surgical procedures should be done first, and allows for comparison across subspecialties and to adult surgical cases.

The scoring system has been used effectively at two medical centers within a larger health system that have the complicated undertaking of providing care to both children and adults. The availability of resources for children compared to that of adults was greater at both sites, essentially because there were fewer restrictions at the level of the state and more available beds and providers. A fundamental change to the scoring system that allowed children’s cases to be scored among adult cases was adjusting the weight in the overall score of the resources required to match the resources available. As the weight given to resource restraints was decreased for children, a greater weight was given to the surgeon-determined urgency of the case for children.

The result of the change was that pediatric cases made up a higher fraction of overall surgical cases in the first months of reactivation in the pandemic. In OL, that fraction rose from 14% in the 12 months prior to the pandemic to 27% during the early reactivation phase. In PR, the fraction rose from 13% to 19%.

An important difference between the two sites was the COVID-19 burden in the surrounding communities. At the peak of the pandemic, the burden in OL was significantly higher compared to that of PR. In the ACH–OL and PR Hospital systems, there were approximately 3100 and 1300 COVID positive patients (including both adults and pediatric patients) respectively during the time period studied. In OL, operating room nursing staff was diverted to assist with adult intensive care units. As a result, fewer elective cases were done in OL compared to PR during early reactivation, despite the fact that the overall surgical volumes in OL are typically higher, both for children and adults. Because of the relatively limited capacity in OL, average pSWAPS scores at that site were lower during reactivation as well. As the COVID-19 burden decreased and more capacity was available, more cases were performed. An increase was noted in the second month on both campuses, and the percentage increase was greater in OL compared to PR. In addition, cases with a higher pSWAPS score were performed at OL during the second month of reactivation.

A significant concern that our institution had in assigning greater weight to surgeon-determined urgency for children’s cases was that it would make the overall score more subjective. To address this, ten elective cases which had been scheduled by a single provider and canceled because of COVID-19 restrictions in March were summarized with brief clinical vignettes, and these were then rated by four children’s surgeons of the same subspecialty (pediatric otolaryngology) using the pSWAPS system. Our interpretation of the Fleiss’ Kappa results is that independent surgeons within a single specialty largely agreed on whether a case qualified or did not qualify for scheduling, using the pSWAPS tool. Those same surgeons, however, did not clearly agree on whether or not the case qualified for immediate or future scheduling using this tool. Ultimately, despite the subjectivity introduced by a greater weight given to case urgency in the case of children, the tool was consistently useful in identifying cases appropriate for scheduling during reactivation.

There are a number of limitations to this scoring system. One of the main shortcomings is the fact that the system was not widely validated across specialties prior to its implementation given the time constraints. In addition, there was no differentiation in the variables for different service lines or surgical subspecialties. Although this aids in the simplicity and transparency of the approach, there may be some nuances of different specialties that are not adequately accounted for. There also is not significant data known about comorbidities and perioperative outcomes in pediatric patients with COVID-19. As such, there may be other patient-related factors that were not addressed.

The advantages of this scoring system include its flexibility, simplicity to use, broad applicability, and objectiveness to facilitate decision-making. It provides a more objective measure for allotting operating room time and mitigates problems of using more of a free-for-all and first-come-first-serve type of approach. In addition, as both adults and children use the operating rooms at both of the hospitals where the scoring system was used, the SWAPS system allows for some type of comparison if required to demonstrate which patient would be allowed to be operated on first.

5. Conclusions

The pSWAPS system is a simple, flexible scoring system that takes into consideration resource constraints, pediatric specific conditions that may contribute to perioperative risk if affected with COVID-19, and the procedure acuity. It has been used for the two months of reactivation in the operating room for elective cases. It has served as an effective tool assisting with a safe and methodical reintroduction of elective procedures during the COVID-19 pandemic and could be used again if another surge occurs.

Declaration of Competing Interest

Nothing to disclose. Disclosures not related to this work: Dr. Slater is a consultant for Boulder Surgical. This disclosure is not relevant for this manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authorship

All authors have materially participated in the article preparation. All authors have approved the final article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jpedsurg.2020.12.011.

References

[1] She J, Liu L, Liu W, COVID-19 epidemic: disease characteristics in children. J Med Virol 2020:52(7):747–54.

[2] Surgeons ACo. COVID-19: guidance for triage of non-emergent surgical procedures 2020 https://www.facs.org/covid-19/clinical-guidance/triage.
[3] Aminian A, Safari S, Razeghian-Jahromi A, Ghorbani M, Delaney CP. COVID-19 outbreak and surgical practice: unexpected fatality in perioperative period. Ann Surg 2020;272(1):e27–ee9.

[4] Collaborative C.O.Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. Lancet 2020.

[5] Prachand VN, Milner R, Angelos P, Posner MC, Fung JJ, Agrawal N, et al. Medically necessary, time-sensitive procedures: scoring system to ethically and efficiently manage resource scarcity and provider risk during the COVID-19 pandemic. J Am Coll Surg 2020.

[6] Slidell MB, Kandel JJ, Prachand V, Baroody FM, Gundeti MS, Reid RR, et al. Pediatric modification of the medically necessary, time-sensitive scoring system for operating room procedure prioritization during the COVID-19 pandemic. J Am Coll Surg 2020.

[7] IDPH. COVID-19 - elective surgical procedure guidance. 2020.

[8] Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. Acta Paediatr 2020;109(6):1088–95.

[9] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159–74.