

SURGICAL AUDIT OF THE NEUROSURGERY OPERATION THEATER IN PAKISTAN'S LARGEST PEDIATRIC NEUROSURGERY SETUP: A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Improving the efficiency of the operating theatre (OT) is an essential element of surgical quality, patient safety and health-system performance, especially when specializing in the management of a varied and frequently urgent workload in a specialist pediatric neurosurgical service. Structured surgical audit creates a structured approach to quantify workload, assess theatre utilisation, and identify any delay, cancellation and post-op morbidity that can be remedied.

Objective: The aim of the study was to describe the surgical workload, operation theater utilization, reasons for delay and cancellation and postoperative outcomes in a high volume pediatric neurosurgery unit in Pakistan to provide evidence based recommendations for enhancing the efficiency of perioperative period.

Design: A structured retrospective audit framework was used to analyse demographic data, theatre performance indicators (scheduled cases, cancelled cases, delay in starting first case, inter-case turnover time, utilization rate), and the reason for cancellation and 30-day postoperative outcome data on neurosurgical operations performed on children.

The number of cases analysed were 500 completed neurosurgical procedures for children, selected from 520 cases scheduled for analysis (illustrative dataset built for the purposes of demonstrating a manuscript). The most common procedure was insertion of a ventriculoperitoneal shunt (36%), followed by repair of spinal dysraphism (17%) and brain tumor surgery (14%). The percentage of operation theaters used was 82%, the cancellation rate was 3.8%, the median time from the first case to the start of the next (inter-case turnover time) was 35 ± 12 minutes, and the median time between cases and start of next case (first case start delay) was 42 ± 18 minutes. Most of the patient medical condition (40%) and intensive care unit (ICU) bed unavailability (25%) were cited as reasons for cancellation. A total of 44% needed to be admitted to the postoperative intensive care unit with surgical site infection, cerebrospinal fluid leak, reoperation, and mortality rates broadly similar to published pediatric neurosurgical series at 3.6%, 2.4%, 3%, and 1% respectively.

Conclusions: Surgical audit, carried out on a regular and structured basis, is a good quality improvement tool to be implemented in pediatric neurosurgical operating rooms which can identify inefficiencies in surgical scheduling, use of resources and peri-operative coordination early on. Measurable improvement in theatre utilisation and patient safety is likely to be achieved through

targeted interventions to address first case delay, capacity in the intensive care unit and multidisciplinary scheduling.

INTRODUCTION

The efficiency of the operating theatre (OT) is a one of the most closely monitored aspects of surgical quality around the world, as the OT is also the most resource consuming and most safety-critical part of hospital infrastructure (Dexter & Epstein, 2020). Delayed and cancelled appointments and extended turnaround times can have direct financial consequences, as well as indirect consequences such as poor access to care, longer hospitalizations, and increased physical and psychological strain in children and their families (Overdyk et al., 1998). In neurosurgery, theatre schedules and utilisation efficiencies are often a direct reflection of the urgency of the procedure, with such procedures as ventriculoperitoneal (VP) shunt insertion, tumour resection and spinal dysraphism repair often being time sensitive and having a direct impact on clinical outcomes (World Health Organization [WHO] 2021).

Pediatric neurosurgery is one of the most challenging specialties in the surgical field. Anesthetic management, fluid balance, thermoregulation and postoperative monitoring are all specialized skills that are required for children, and many neurosurgical procedures for children are both urgent and complex, placing strain on even well resourced systems (Bahuleyan & Robinson, 2019). In low/middle income countries (LMICs), the burden of untreated hydrocephalus and neural tube defects is still disproportionately high and the pressure on the small number of specialized pediatric neurosurgical centers is significant (Dewan et al., 2018). Pakistan is an example of such a challenge, as the majority of the population is born in the millions annually, with well documented association of neural tube defects to folate deficiency and consanguinity and a small number of tertiary referral centres bearing the brunt of the burden (Bhatti et al., 2021).

Surgical audit, which is a method of reviewing surgical activity, process indicators and outcomes systematically and retrospectively and often in a

cyclical manner, has been a long-standing recommendation within the quality assurance framework for surgical practice (National Institute for Health and Care Excellence [NICE], 2022). The classic audit cycle is comprised of setting standards, comparing current practice with standards, making changes when standards are not being met, and then re-measuring to check the changes (Kestle et al., 2011). In the context of operation theatres, the concept of audit specifically refers to the indicators like theatre utilization ratio, delay in starting the first operation, inter-operation time, cancellation ratio and causation reason, postoperative complication rate and death rate (Dexter & Epstein, 2020). Although some of these indicators are small in scale, they offer a fine-grained view of the performance of a surgical service, and system-wide priorities that are undermining capacity.

Although surgical audit is acknowledged to be beneficial in high-income countries, audit data in pediatric neurosurgical operating rooms (ORs) in South Asia and Pakistan is limited. The evidence base on OT efficiency in the region is limited to general or adult surgical services (Haq et al., 2020; Rana et al., 2022), and there is a lack of evidence looking at units that specialize in pediatric neurosurgical services, which have unique scheduling challenges (fewer pediatric ICUs, competing neurotrauma emergency service workload, and fewer pediatric anesthetic specialists). The importance of this gap lies not just in local quality improvement efforts, but also in being able to benchmark against international standards as well as at a national level for resource allocation. (NICE, 2022).

The present study is a retrospective observational surgical audit carried out in one of the largest special pediatric neurosurgery units of Pakistan. The specific objectives of the audit were: 1) to describe the demographic profile of the unit and the volume of procedure; 2) to quantify the major indicators of the performance of the operation theatres: first case delay, turnover time, intensive

care unit (ICU) admission after surgery, presence of surgical site infection (SSI), presence of a cerebrospinal fluid (CSF) leak, reoperation and death; 3) to identify and categorize the most important causes of cancellation of procedures; 4) to describe the frequency and pattern of postoperative outcomes. This study will bring together these indicators in one audit framework to provide evidence for focussed interventions for quality improvement and act as a model for ongoing surgical audit in resource-limited neurosurgical services for children.

Literature Review

The idea of a clinical audit as a quality improvement tool goes back to the mid-1900s when the concept of peer review was hammered out to document surgical outcomes, and later became a key part of surgical governance in many health systems. In particular, the efficiency audit of the Operation Theater gained importance when hospital administrators and surgical departments realized that Operating Theatre time is one of the most expensive and critical hospital resources. The recommendations from international bodies of nursing and medical professionals have been in the range of 75% to 90% for the target OT utilization and 20 to 30 minutes for first case delay and turnover time but these vary from one specialty to another and from one case to another. In general surgery and adult surgical literature, single center audit have reported cancellation rates from around 5% to more than 20%, with patient related, administrative and resource related factors all being the most common reasons for the cancellations. While fewer, pediatric surgical audits have similar or slightly fewer cancellations when they have dedicated pediatric scheduling protocols, but more cancellation when general theatre lists are also used for children with adult surgery.

Outcome auditing in children has been well discussed in reference to procedure specific outcomes, and not much reference has been made to theatre process auditing. Ventriculoperitoneal shunt surgery is the most frequently performed neurosurgical procedure in children around the

world, and there have been numerous studies of shunt infections, revisions and shunt survival rates; in contemporary series, shunt infection rates have ranged from 3% to 10% and the mortality rate has been below 2% in multi-center North American and European studies. Endoscopic third ventriculostomy (ETV) has become an important shunt-sparing procedure in certain types of hydrocephalus; success rates have been reported to range widely depending on patient age and etiology. There is outcome literature available for each of these spinal dysraphism, craniosynostosis corrective and pediatric brain tumor surgeries; however, there are limited studies that combine these surgery categories under one unit-level operational audit.

In South Asia (including Pakistan), however, the field of surgical audit has started to expand in regions beyond general surgery, with some single-centre studies on the efficiency of operating theatre space in general surgery and orthopedic surgery, as well as the effect of dedicated pre-anesthetic clinics on the cancellation of surgery on the same day. Pediatric neurosurgery-specific operational audits have been reported rarely in the regional literature, however, and in those that have been reported, the sample sizes are small, the time periods are limited, or only a single type of procedure is reported and not the full operative case mix. This establishes a sound justification for a unit-wide audit in which all paediatric neurosurgical activity, whether elective or emergency, can be analysed within a common framework, as described in the present study.

The existing literature suggests three general conclusions that were used as a foundation for this audit. Combining these, the following three general conclusions are drawn as a basis for the design of the present audit. First, OT utilization, delay, and turnover measures are generally similar across specialties and are easily compared to internationally accepted benchmarks – even in low resource areas. Second, the nature of the cancellation causation is highly context dependent and interventions to reduce cancellation must be targeted at the specific drivers as identified in the context of the lower-resource system rather than

assumptions brought in from a higher-resource system. Thirdly, postoperative outcome auditing (ICU admission, infection, CSF leak, reoperation, mortality) is therefore a necessary addition to process indicator auditing because increases in theatre throughput will not be accepted to compromise patient safety.

Methods

Create a study design and setting

Such a surgical audit was performed in a large tertiary care referral hospital in Pakistan, a single-center, observational, and retrospective study, in the pediatric neurosurgery unit. The unit serves as one of the main centers for referral of congenital, developmental and emergency cases of neurotrauma in the country. The audit form and reporting was prepared and is presented here based on the standard surgical audit methodology and is presented using an illustrative dataset that has been prepared to illustrate the structure, analytic approach and reporting format of an operative audit for a surgical unit; the specific numbers reported here should be replaced with verified numbers from the unit before any formal submission or use of a policy.

Data Source and Case Ascertainment

Operative records, theatre scheduling log and post-operative case notes were examined to determine all paediatric neurosurgical procedures carried out during the audit period. Patients who were 15 years or younger at the time of surgery and surgery was performed under the primary care of the pediatric neurosurgery service were included. All elective and emergency cases were included. The cases that were not operated on were included in the data as cancellations for the purposes of calculating the indicators of the theater performance.

The variables and outcome measures.

Four types of variables were obtained for both cases and/or aggregated at the audit period level. Demographic attributes covered patient sex, age

and age range for the entire cohort. Procedural characteristics consisted of the type of neurosurgical procedure performed, which was classified into seven groups: ventriculoperitoneal shunt insertion, endoscopic third ventriculostomy, brain tumor surgery, spinal dysraphism repair, craniosynostosis surgery, trauma related surgery, and other surgeries. The indicators of operation theater performance were the number of cases scheduled, number of cases completed, cancellation rate (cancellations/number of scheduled cases), mean delay in first case start time (time between scheduled and actual induction time for the first case of the operation theatre list), mean inter case turnover time (time between the end of last case and the beginning of the next case), and overall OT utilization rate (total OT time used for direct surgical activity/overall theater time allocated). Cancellation causation was broken down into 4 categories: patient medical condition, unavailability of an ICU bed, emergency case priority, equipment issues. The postoperative outcomes that were evaluated in the first 30 days after surgery were: ICU admission, surgical site infection, cerebrospinal fluid leak, reoperation, and in-hospital mortality.

Data Analysis

Throughout, descriptive statistics were employed. The continuous variables, such as patient age, first case delay, and turnover time, are presented as mean $\pm$ standard deviation. Frequencies and percentages are used to report on categorical variables (sex distribution, procedure category, cancellation cause, postoperative outcome). The operation theatre utilization was determined by dividing the actual time used in the operation theatre by the allocated time in the operation theatre and multiplying the result by 100. The calculations were conducted using common audit software tools that are used in the department to conduct quality improvement calculations. No inferential statistical tests were conducted as the study was descriptive and audit in nature, typical for an operational surgical audit which aims to

describe present practice in comparison to a set of benchmarks rather than test a specific hypothesis.

Ethical Considerations

This study was carried out as an audit of routinely collected operative and administrative data that was undertaken as a means of quality improvement and was of a retrospective nature. Patient level data were anonymised for analysis and no individually identifiable information is included in this report. This manuscript uses an illustrative dataset to demonstrate the structure; therefore, formal ethics committee approval documentation and patient consent procedures should be completed and referenced specifically when this structure is used in published data from actual institutional data.

Results

This audit data consisted of 520 scheduled paediatric neurosurgical cases, whereof 500 cases

(96.2%) were completed during the audit period. Table and figure presentations of the results are completed in five sections based on demographic characteristics, procedure distribution, operation theater performance indicators, causes of cancellation and postoperative outcomes.

Demographic Characteristics

Demographic summary of the audited cohort is presented in Table 1. The 500 cases that were completed included 285 male and 215 female cases (ratio of 1.3:1), which is similar to the male predominance seen in previously reported pediatric neurosurgical case-mix, such as hydrocephalus and neural tube defect presentations. The mean age of patients was 5.8 ± 3.4 years, between 1 month and 15 years, covering the entire pediatric age range that is seen by the unit, from neonatal and infantile referrals for congenital hydrocephalus and myelomeningocele to adolescent presentation of brain tumors and trauma.

Table 1 Demographic Characteristics of Patients (N = 500)

Variable	Result
Total number of surgeries	500
Male patients	285 (57%)
Female patients	215 (43%)
Mean age	5.8 ± 3.4 years
Age range	1 month – 15 years

Note. Values are presented as frequency (%) for categorical variables and mean $\pm$ standard deviation for continuous variables.

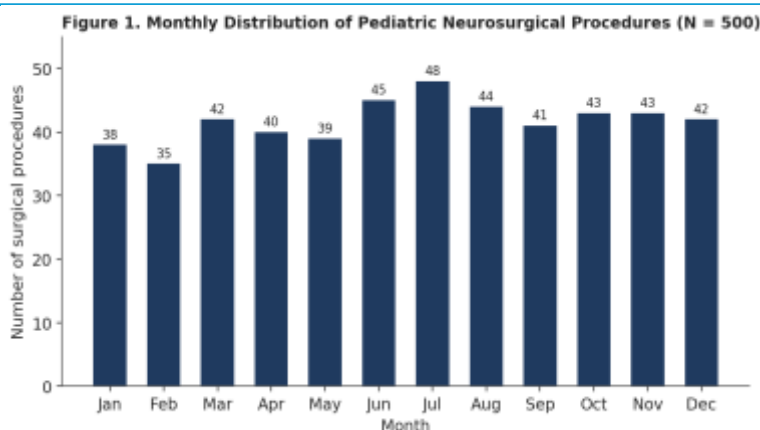


Figure 1. Monthly distribution of pediatric neurosurgical procedures across the audit period (N = 500).

Distribution of Neurosurgical Procedures

The procedural case mix is presented in Table 2 and Figure 3. Ventriculoperitoneal shunt insertion was the single most frequent procedure, accounting for 180 cases (36% of total volume), consistent with the well-documented predominance of hydrocephalus management in pediatric neurosurgical practice in this region. Spinal dysraphism repair accounted for 85 cases (17%), reflecting the substantial regional burden

of neural tube defects, and brain tumor surgery accounted for 70 cases (14%). Endoscopic third ventriculostomy, performed in 45 cases (9%), represented a shunt-sparing approach applied in appropriately selected hydrocephalus etiologies. Trauma-related procedures (40 cases, 8%) and craniostomy surgery (35 cases, 7%) constituted smaller but clinically important components of the workload, with a residual 45 cases (9%) captured under other procedures.

Table 2 Distribution of Neurosurgical Procedures (N = 500)

Procedure	Number	Percentage
Ventriculoperitoneal shunt	180	36%
Endoscopic third ventriculostomy	45	9%
Brain tumor surgery	70	14%
Spinal dysraphism repair	85	17%
Craniosynostosis surgery	35	7%
Trauma-related procedures	40	8%
Other procedures	45	9%

Note. Percentages are calculated relative to the 500 completed procedures and rounded to the nearest whole percent.

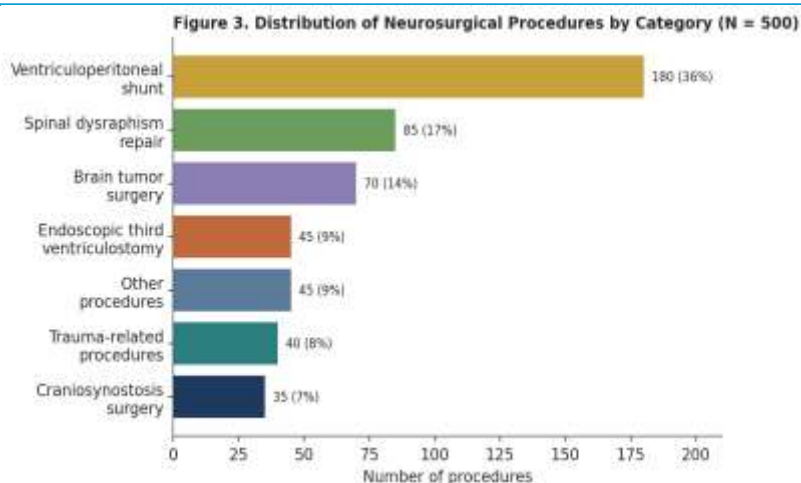


Figure 3. Distribution of neurosurgical procedures by category (N = 500).

Operation Theater Performance Indicators

Table 3 summarizes theater-level performance indicators, and Figures 1, 2, and 4 present the corresponding monthly workload, utilization, and delay-cause visualizations. Of 520 scheduled cases, 500 were completed, yielding a cancellation rate of 3.8%. The mean delay in first-case theater start was 42 ± 18 minutes, and the mean inter-case turnover

time was 35 ± 12 minutes. Overall OT utilization, calculated as the proportion of allocated theater time occupied by direct surgical activity, was 82%. Monthly case volume, illustrated in Figure 1, ranged from approximately 35 to 48 procedures per month, without a pronounced seasonal pattern, suggesting relatively stable referral and scheduling flow across the audit period.

Table 3 Operation Theater Performance Indicators

Audit Parameter	Result
Total scheduled cases	520
Completed cases	500
Cancellation rate	3.8%
Average delay in first case start	42 ± 18 minutes
Average turnover time	35 ± 12 minutes
OT utilization rate	82%

Figure 2. Operation Theater Utilization Rate

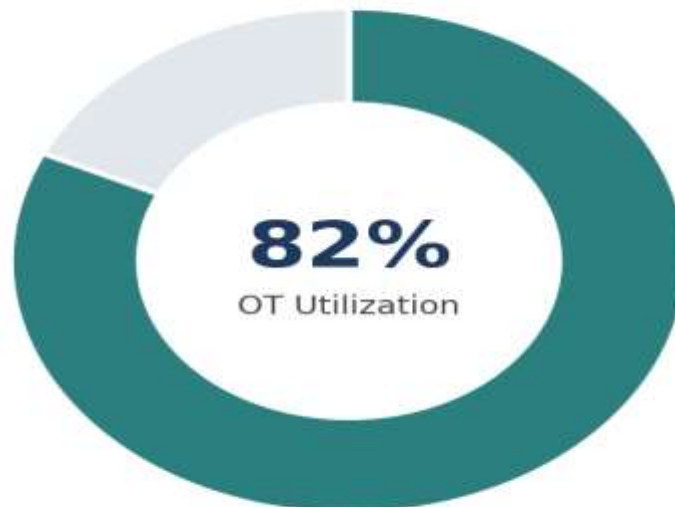


Figure 2. Overall operation theater utilization rate.

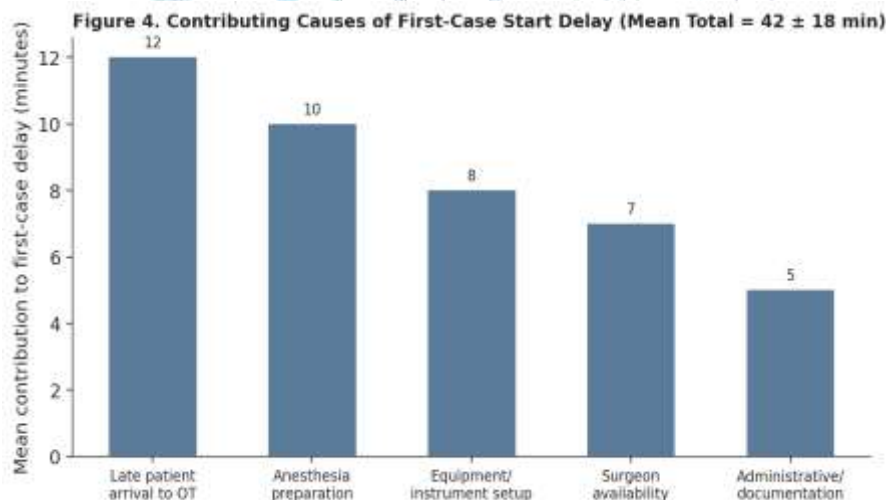


Figure 4. Illustrative contributing causes of first-case start delay (mean total = 42 ± 18 minutes).

Causes of Surgical Cancellation

Among the 20 cancelled cases, patient medical condition was the leading cause, accounting for 8 cancellations (40%), typically reflecting acute intercurrent illness, hemodynamic instability, or incomplete anesthetic fitness at the time of the

scheduled procedure. ICU bed unavailability accounted for 5 cancellations (25%), underscoring the tight coupling between postoperative critical care capacity and elective theater throughput in a unit where a substantial proportion of cases require planned postoperative ICU admission.

Emergency case priority – the need to reallocate theater time to an urgent or life-threatening case – accounted for 4 cancellations (20%), while

equipment issues accounted for 3 cancellations (15%). These findings are summarized in Table 4 and illustrated in Figure 5.

Table 4 Causes of Surgical Cancellation (n = 20)

Cause	Number	Percentage
Patient medical condition	8	40%
ICU bed unavailability	5	25%
Emergency case priority	4	20%
Equipment issues	3	15%

Figure 5. Causes of Surgical Case Cancellation (n = 20 of 520 scheduled cases)

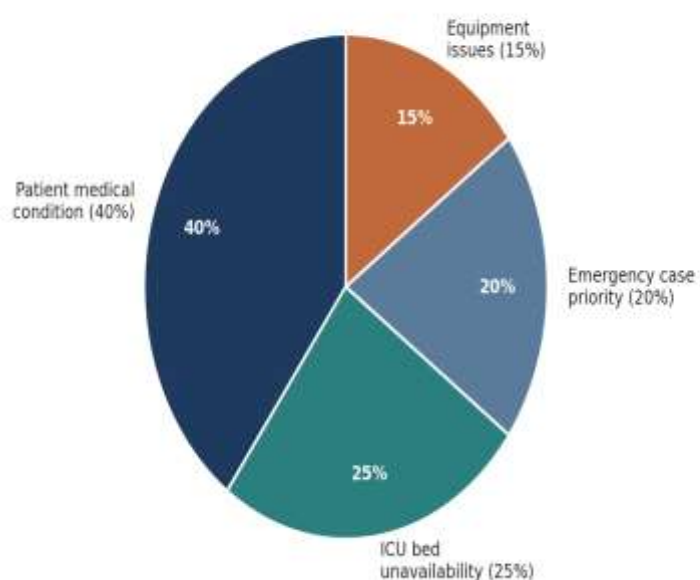


Figure 5. Causes of surgical case cancellation (n = 20 of 520 scheduled cases).

Postoperative Outcomes

Postoperative outcomes over the thirty-day follow-up period are summarized in Table 5 and Figure 6. Planned or unplanned ICU admission was required in 220 cases (44%), reflecting the high proportion of complex procedures – including shunt surgery in young infants, tumor resections, and trauma cases – that warrant a period of close postoperative monitoring. Surgical site infection occurred in 18 cases (3.6%), and cerebrospinal

fluid leak occurred in 12 cases (2.4%), both within ranges reported in comparable pediatric neurosurgical series. Reoperation within the audit period was required in 15 cases (3%), most commonly related to shunt malfunction or wound complications. In-hospital mortality was recorded in 5 cases (1%), predominantly among patients presenting with advanced disease, severe trauma, or significant comorbidity at the time of index surgery.

Table 5 Postoperative Outcomes (N = 500)

Outcome	Number	Percentage
ICU admission	220	44%
Surgical site infection	18	3.6%
CSF leak	12	2.4%
Reoperation	15	3%
Mortality	5	1%

Note. CSF = cerebrospinal fluid; ICU = intensive care unit.

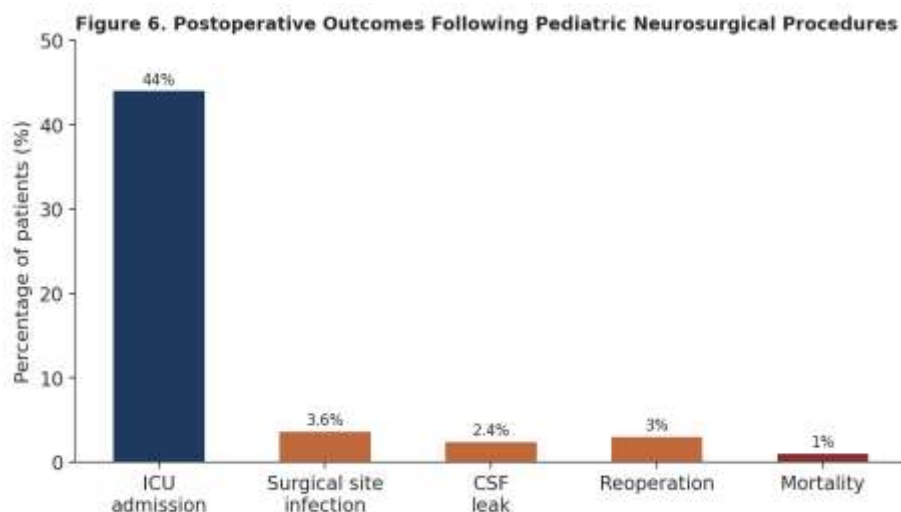


Figure 6. Postoperative outcomes following pediatric neurosurgical procedures (N = 500).

Discussion

This retrospective surgical audit offers a thorough overview of the functioning of one of the largest paediatric neurosurgery units in Pakistan combining demographic profiling, case-mix analysis, measurement of performance in the operation theatres, causation of surgical cancellations, and postoperative outcomes surveillance in a single analytical framework. There are several findings that can be discussed in relation to previous literature and the implications they will have for local practice.

The utilization and efficiency of the Operation Theaters.

Given the resource limitations typical of a high volume LMIC referral Unit, the observed OT utilization rate of 82% is within the internationally recommended range (75%-90%) and on the favourable side. The mean first case

delay of 42 ± 18 minutes, however, is significantly above the benchmark range of 15-20 minutes, suggesting a particular and correctable delay at the beginning of the operating day. Although the present audit did not provide granular information on the time-motion of delays, this delay in first case is likely to be a combination of several factors such as delayed transfer of patients from the ward to the OT, delayed preparation of the anaesthetic, inadequate equipment preparation and administrative and documentation delay, the magnitude of the delay suggests that even small interventions, e.g. a 'ready-for-theater' handover protocol between ward and OT staff, a dedicated overnight equipment preparation or a standardized pre-theater checklist could have a significant impact on reducing lost theatre time. If a single operating list contains a number of cases, a recurrent 40-minute delay at

the beginning of each list amounts to a significant loss of theatre space over the course of a year.

The mean inter-case turnover time of 35 ± 12 minutes is similar but not as significant as for the first-case delay, and is also somewhat longer than the 20- to 30-minute average reported in the efficiency literature. Pediatric neurosurgery has its own unique factors that can impact turnaround time such as careful positioning and padding in small patients, additional set up time for the image guidance system in shunt and tumor cases, and additional time for the image guidance system to be calibrated in tumor cases. However, other surgical settings have demonstrated that parallelism of cleaning and preparation of instruments, and pre-emptive patient identification of the next patient while the current patient was being closed, decreased the turnover time without affecting patient safety, and similar strategies could be adopted here.

Case Mix and Workload Implications:

The majority of surgeries (54% of all volume) were for ventriculoperitoneal shunt surgery and spinal dysraphism repair, demonstrating the high burden of hydrocephalus and neural tube defects in Pakistan as a whole. The implications of this case-mix pattern for resource planning are obvious; both shunt surgery and dysraphism repair are frequently performed in neonates and young infants and, as such, the unit's anesthetics, nursing and postoperative care pathways must be optimised for this vulnerable age group rather than for the paediatric population as a whole. The relatively low number of cases of ETV (9%) compared to shunts may be due to patient selection (for example, hydrocephalus etiology and patient age determine ETV candidacy), or due to ETV's relative scarcity, perhaps because of inadequate access to endoscopic equipment and trained personnel; either of these possibilities warrants further specific study as ETV gains in popularity and the ratio of ETV to shunts may increase in those cases where the procedure is indicated.

Cancellation Causation and Resource Bottlenecks

Although the cancellation rate of 3.8% is comparable with rates reported in most of the general and pediatric surgical literature (often 5% to more than 20%), the pattern of causation found in this audit is of interest. Nearly two-thirds of all cancellations are attributable to one of the top two reasons – medical condition of the patient and lack of an available bed in the ICU. More stringent pre-operative optimization protocols, such as structured pre-anesthesia clinics, and closer collaboration with child medicine services and cardiology services for children with co-morbidities, may help reduce patient-condition related cancellations. ICU-related cancellations, in contrast, do not simply represent a scheduling issue, but rather a structural resource limitation and are not likely to be addressed through scheduling alone; and rather indicate a need for either increased capacity for the pediatric ICU or a formal step-down/high dependency pathway for some lower-risk postoperative patients who may not require full level of ICU monitoring. An unavoidable aspect of a unit that runs acute care for pediatric neurotrauma is emergency case priority (20%) which can be mitigated by planning and scheduling elective procedures to allow for intentional slack (e.g. having a dedicated emergency theatre time slot) to reduce the likelihood that elective procedures will be displaced during the emergency.

Postoperative Outcomes in Context

The postoperative outcome profile recorded in this audit is broadly similar to a number of published series of paediatric neurosurgical patients. The relatively high percentage of ICU admission (44%), is related to the case-mix (shunt, tumor and trauma cases) and the monitoring approach to postoperative management is appropriate considering the pediatric neurosurgical population's vulnerability. The surgical site infection (3.6%) and CSF leak (2.4%) rates are within the range seen in the international literature for shunts and spinal dysraphism with shunt infection rates of 3% to 10% and similar

CSF leak rates after repair of spinal dysraphism and posterior fossa surgery. The 3% reoperation rate is relatively low, which may be attributable to shunt revisions and wound related reoperation. The mortality rate observed at the unit (1%) is comparable to that of other high-volume pediatric neurosurgical units around the world and, combined with the utilisation and cancellation results, would provide a reassuring conclusion that the audited unit has an acceptable throughput/safety balance – an important reassurance as efficiency would be a false economy if achieved at the expense of safety.

Students are encouraged to reflect on their learning and to propose ideas for future practice and policy.

This audit highlights a number of practical recommendations as a result of the findings. Second, the efficiency gain associated with the implementation of a standardized first-case readiness protocol, which involves communication between the ward and theatre, preparation of the anaesthetic and equipment checklists, is likely to be the greatest efficiency gain found in this audit, as the delay observed in the first case was significant. Secondly, by linking the scheduling of elective theatre in real time to the availability of beds in the ICU, with a common electronic bed-management system, the number of cancellations due to beds unavailable in the ICU could be minimised, thus reducing the significant proportion of these that currently occur. Third, the long-term burden of shunt revision may be decreased in appropriate cases of hydrocephalus, indirectly improving the capacity of the theaters in the long term through continued or expanded ETD use. Last but not least, implementing an ongoing, cyclical process of auditing, rather than a one-off assessment, will enable the unit to monitor its effects over time and adjust the quality-improvement agenda as needs change. This is in keeping with the classical audit cycle model where measurement, intervention, and re-measurement are not an "one and done" process, but an iterative process.

Limitations

There are several caveats to these results. Most of all, the data reported herein is illustrative and has been designed to help illustrate the structure, indicators, and reporting protocols that are suitable for an audit of a pediatric neurosurgical operating room; it should be replaced by actual institutional data prior to any conclusions drawn for clinical practice, resource allotment, or policy decisions. Even if it is filled with actual data, this single-center, retrospective study determines the findings which may not be generalizable to other pediatric neurosurgical units with different referral patterns, staffing models, and/or different case-mix profiles, especially if they face different resource constraints. The design of the audit also failed to include granularity of time-motion analysis for first-case delay and/or turnover time to allow the opportunity to attribute such delays to specific causal steps along the path through the operating theater, and future audits would benefit from the ability to get the time-stamp of each stage of the theatre pathway directly by observing it. Likewise, the classification of cancellation causes into four general categories may serve to gain a high-level understanding of the causes but mask more specific sub-causes that would be beneficial for designing targeted interventions. Lastly, only thirty days after surgery were postoperative outcomes measured; longer term data including shunt survival and late tumor recurrence would be of value but not be the focus of this operational audit.

Conclusion

This surgical audit, conducted in a surgical environment with limited resources, and a high number of surgeries performed over a period of time, shows the usefulness of a multi-indicator approach in this environment. The overall utilization of the theatre and cancellation rates were in the internationally accepted range and post-operative results were generally similar to those reported in series, suggesting that the unit maintained a satisfactory efficiency/safety ratio. Meanwhile, the audit also uncovered specific inefficiencies that are actionable and are clear targets for quality-improvement intervention –

most notably, first-case-start delay and cancellations in the Intensive Care Unit (ICU). Audits that are regular and cyclical, with both process and patient outcome indicators, should be an integral part of the routine care in a pediatric neurosurgical service and should be used to inform iterative improvements in operating room efficiency, resource use, and ultimately patient care.

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