

# Postoperative Outcome in Children Aged between 6 and 10 Years in Major Abdominal Surgery, Neurosurgery and Orthopedic Surgery

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## Abstract

**Background:** Anticipating postoperative evolution in surgical patients is an important issue in our daily practice. We demonstrated in a previous study that there were multiple predictors of postoperative outcome, including American Society of Anesthesiologists status (ASA), transfusion, emergency, surgery and age. A secondary analysis describing intraoperative and postoperative outcomes was undertaken in children aged between 6 and 10 years old included in the initial study. **Objective:** To describe intraoperative and postoperative outcomes in children aged between 6 and 10 years old included in the initial cohort in abdominal surgery, neurosurgery and orthopedics. **Methods:** The secondary analysis of postoperative outcomes in children aged between 6 and 10 years old was retrospectively included in the initial study of 594 patients. The study was approved by the Ethics Committee. **Results:** There were 88 patients with a mean age of  $98.7 \pm 13.8$  months. The most common surgical interventions were scoliosis in 23 patients (26.1%), limb tumor resection in 8 patients (9.1%), femoral osteotomy in 6 patients (6.8%), intracerebral tumor resection in 6 patients (6.8%), intestinal resection in 5 patients (5.6%), Chiari's malformation in 4 patients (4.5%), pelvic osteotomy in 4 patients (4.5%) and renal transplantation in 4 patients (4.5%). Most patients (45%) were American Society of Anesthesiologists grade 3 (ASA 3), and 13 (14.8%) were ASA grade 4. Twenty-two (25%) patients had intraoperative and/or postoperative complications (organ dysfunction or sepsis). Two patients (2.3%) had intraoperative hemorrhage, 1 patient (1.1%) had intraoperative difficult intubation, and 1 patient experienced intraoperative anaphylaxis. Nine patients (10.2%) had postoperative neurologic failure, and 2 (2.3%) had postoperative cardio-circulatory failure. Three patients (3.4%) had postoperative septicemia, 2 patients (2.3%) had postoperative pulmonary and urinary

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sepsis, and 1 patient (1.1%) had postoperative abdominal sepsis. 3 patients (3.4%) had re-operations. 42 (47.7%) patients had intra-operative transfusion. There was 1 in-hospital death (1.1%). The median total length of hospital stay was 9 days [5 - 16]. **Conclusion:** Twenty-five percent of the patients had intraoperative and/or postoperative complications, and most of them were ASA grade  $\geq 3$ . Integrating goal-directed therapies to optimize intraoperative management in these patients could be necessary to improve postoperative outcomes in surgical pediatric patients.

## Keywords

Children, Abdominal Surgery, Neurosurgery, Orthopedics, Outcome, Goal-Directed Therapies

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## 1. Introduction

Postoperative outcomes in surgical patients are an important issue in our daily practice.

Predictors of postoperative outcome are multifactorial, among which American Society of Anesthesiologists status (ASA), transfusion, emergency, surgery and age were identified in previous studies [1] [2] [3] [4]. The ASA score (I-V) is a scale used in anesthesia to assess patient severity physical status: ASA I: normal healthy patient, ASA II: patient with mild systemic disease, ASA III: patient with severe systemic disease, ASA IV: patient with a severe systemic disease which is constantly threatening life, ASA V: the moribund patient who is not expected to survive without surgery.

Predictors of postoperative outcome in this study were not exhaustive, which means that other nonidentified factors may contribute to how patients evolve after surgery.

For a better postoperative outcome, anticipating patient management optimization begins preoperatively and continues intraoperatively and postoperatively. Intraoperative patient optimization includes fluid and hemodynamic goal-directed therapy with tools validated in children, blood patient transfusion protocols guided with point-of-care tests in hemorrhagic surgery and enhanced recovery after surgery protocols [5]-[13]. These goal-directed therapies have been shown in adults to improve postoperative outcomes [14]. In children, goal-directed therapies are not well developed and are not in routine generalized practice.

The study presented here had the objective of describing postoperative outcomes in children aged between 6 and 10 years who were included in the initial retrospective study [1]. The aim was to emphasize how these patients evolved after major surgery and to propose improvement implementation protocols.

## 2. Methods and Materials

A secondary analysis of children between 6 and 10 years old was included in the

initial study [1].

The study was declared to the CNIL, National Commission for Computer Science and Liberties on 21 February 2017 under the registration number 2028257 v0. The Ethics Committee of Necker approved the study on 21 March 2017 under registration number 2017-CK-5-R1. Patients were included retrospectively from 1 January 2014 to 17 May 2017.

**Figure 1** illustrates the inclusion and exclusion criteria flow chart.

The inclusion criteria were children aged between 6 and 10 years old.

The exclusion criteria were children aged less than 6 years old and older than 10 years.

Statistics were analyzed with XLSTAT 2020.4.1 software.

Continuous variables were described as the means  $\pm$  standard deviation or medians with interquartile ranges. Category variables were described in proportions.

### 3. Results

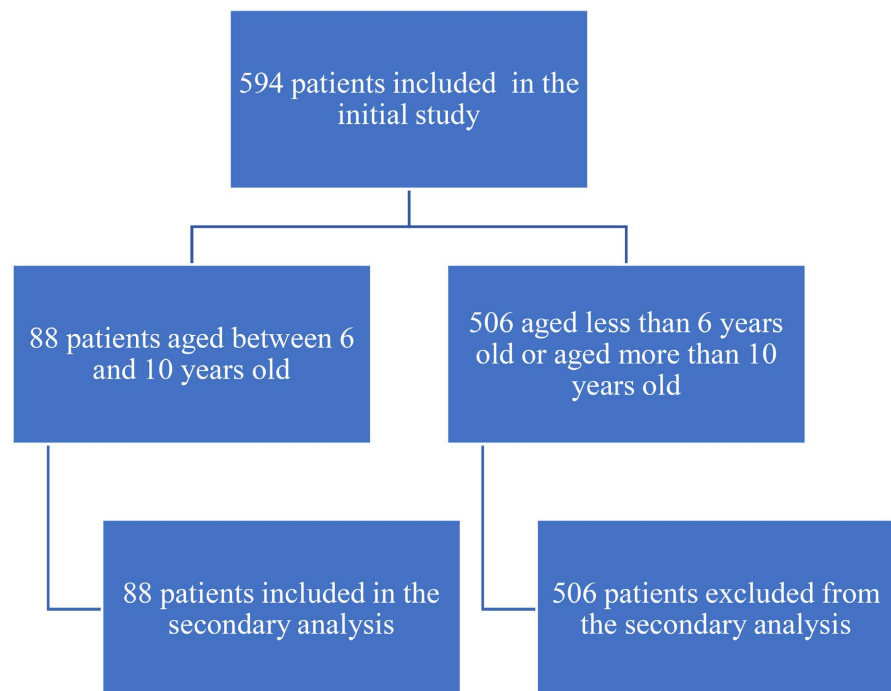
**Table 1** illustrates the general characteristics.

There were 88 patients with a mean age of  $98.7 \pm 13.8$  months.

There were 17 patients (19.3%) who underwent abdominal surgery, 26 (29.5%) who underwent neurosurgery and 45 (51.1%) who underwent orthopedic surgery. 11 patients (12.5%) had an emergency intervention.

**Table 2** illustrates types of surgery.

The most common surgical interventions were scoliosis in 23 patients (26.1%), limb tumor resection in 8 patients (9.1%), femoral osteotomy in 6 patients (6.8%),



**Figure 1.** Inclusion and exclusion criteria flow chart.

**Table 1.** General characteristics.

| Characteristics  | N = 88          |
|--|-----------------|
| Mean age in months $\pm$ standard deviation  | 98.7 $\pm$ 13.8 |
| Abdominal surgery n (%)  | 17 (19.3)       |
| Neurosurgery n (%)   | 26 (29.5)       |
| Orthopedic surgery n (%)   | 45 (51.1)       |
| Elective surgery n (%)   | 77 (87.5)       |
| Emergency surgery n (%)  | 11 (12.5)       |
| Re-surgery n (%)   | 3 (3.4)         |
| Patients with intra-operative and or postoperative complications (organ failure and or sepsis) n (%) | 22 (25)         |
| Intra-operative hemorrhagic shock n (%)  | 2 (2.3)         |
| Intra-operative difficult intubation n (%)   | 1 (1.1)         |
| Intra-operative anaphylaxis n (%)  | 1 (1.1)         |
| Postoperative neurologic failure n (%)   | 9 (10.2)        |
| Postoperative cardio-circulatory failure n (%)   | 2 (2.3)         |
| Postoperative endocrinal failure n (%)   | 1 (1.1)         |
| Postoperative miscellaneous n (%)  | 1 (1.1)         |
| Postoperative multi-organ failure n (%)  | 1 (1.1)         |
| Postoperative septicemia n (%)   | 3 (3.4)         |
| Postoperative pulmonary sepsis n (%)   | 2 (2.3)         |
| Postoperative urinary sepsis n (%)   | 2 (2.3)         |
| Postoperative abdominal sepsis n (%)   | 1 (1.1)         |
| In hospital Mortality n (%)  | 1 (1.1)         |
| Transfusion n (%)  | 42 (47.7)       |
| Mean preoperative hemoglobin levels $\pm$ standard deviation g/dL                                    | 11.6 $\pm$ 1.9  |
| Mean postoperative hemoglobin levels $\pm$ standard deviation g/dL                                   | 10.9 $\pm$ 1.5  |
| ASA I n (%)  | 3 (3.4)         |
| ASA II n (%)   | 31 (35.2)       |
| ASA III n (%)  | 40 (45.5)       |
| ASA IV n (%)   | 13 (14.8)       |
| ASA V n (%)  | 1 (1.1)         |
| Median length of intensive care unit stay in days [interquartile range]                              | 4 [1 - 6]       |
| Median length of hospital stay in days [interquartile range]   | 6 [3.7 - 10.2]  |
| Median total length of hospital stay in days [interquartile range]                                   | 9 [5 - 16]      |
| Median length of mechanical ventilation (invasive or non-invasive) in days [interquartile range]     | 0 [0 - 1]       |

**Table 2.** Surgery.

| Surgery  | Number of patients (%) |
|--|------------------------|
| Basal skull schwannoma   | 3 (3.4)                |
| Brainstem lesion resection   | 1 (1.1)                |
| Cerebral aneurysm/Cerebral arterio-venous malformation angioembolization | 1 (1.1)                |
| Cerebral cavernoma   | 1 (1.1)                |
| Chiari's malformation  | 4 (4.5)                |
| Craniosynostosis   | 3 (3.4)                |
| Epileptogenic lesion resection   | 1 (1.1)                |
| Femoral osteotomy  | 6 (6.8)                |
| Femoral prosthesis   | 1 (1.1)                |
| Hepatic tumor  | 1 (1.1)                |
| Interscapular thoracic desarticulation                                   | 2 (2.2)                |
| Intestinal resection   | 5 (5.6)                |
| Intracerebral tumor resection  | 6 (6.8)                |
| Knee prosthesis  | 1 (1.1)                |
| Laparotomy for volvulus  | 1 (1.1)                |
| Limb tumor resection   | 8 (9.1)                |
| Liver transplantation  | 3 (3.4)                |
| Neuroblastoma  | 1 (1.1)                |
| Orbital tumor  | 1 (1.1)                |
| Pelvic osteotomy   | 4 (4.5)                |
| Pelvic tumor   | 1 (1.1)                |
| Posterior fossa decompression  | 1 (1.1)                |
| Renal transplantation  | 4 (4.5)                |
| Scoliosis  | 23 (26.1)              |
| Splenectomy  | 1 (1.1)                |
| Ventriculostomy  | 1 (1.1)                |
| Vertebral laminectomy/Arthrodesis  | 3 (3.4)                |

intracerebral tumor resection in 6 patients (6.8%), intestinal resection in 5 patients (5.6%), Chiari's malformation in 4 patients (4.5%), pelvic osteotomy in 4 patients (4.5%) and renal transplantation in 4 patients (4.5%).

Most patients (45%) were ASA grade 3, and 13 (14.8%) patients were ASA grade 4.

Twenty-two (25%) patients had intraoperative and/or postoperative complications (organ dysfunction or sepsis).

The most common intraoperative complication was hemorrhagic shock in 2 patients (2.3%), followed by difficult intubation and anaphylaxis in 1 patient (1.1%). The most common postoperative organ failure was neurologic in 9 patients (10.2%), followed by cardio-circulatory in 2 patients (2.3%). The most common postoperative infection was septicemia in 3 patients (3.4%), followed by pulmonary and urinary sepsis in 2 patients (2.3%) and abdominal sepsis in 1 patient (1.1%). 3 patients (3.4%) had re-operations. 42(47.7%) patients had intra-operative transfusion. There was 1 in-hospital death (1.1%) (**Table 3**).

The median total length of hospital stay was 9 days [5 - 16].

**Table 4** illustrates outcomes per surgery.

**Table 5** illustrates co-morbidities. The most common comorbidities were intracerebral tumor in 7 patients (7.9%), Ewing's sarcoma in 5 patients (5.7%), psychomotor deficiency in 5 patients (5.7%), arthritis in 4 patients (4.5%), cerebral anoxic lesions in 4 patients (4.5%), chronic renal failure in 4 patients (4.5%), hepatic failure in 4 patients (4.5%) and polymalformation syndrome in 4 patients (4.5%).

#### 4. Discussion and Conclusion

The rate of patients with intraoperative and/or postoperative complications in this cohort of 88 children between 6 and 10 years of age who underwent major abdominal surgery, neurosurgery and orthopedics was 25%. These patients were in the majority ASA grade 3 or more. As revealed in the initial studies [1] [2] [3] [4], the postoperative outcome depends on multiple factors, precisely ASA status, transfusion, age, emergency and surgery. Integrating goal-directed therapies for intraoperative management in these patients could be necessary to improve postoperative outcomes in pediatric surgical patients. Goal-directed therapies include intraoperative fluid and hemodynamic goal-directed therapy with validated tools in children, intraoperative transfusion goal-directed protocols with point-of-care devices to guide blood product administration and enhanced recovery after surgery [5]-[13]. All these therapies have the same aim, which is to optimize the relation between oxygen consumption and oxygen delivery [6] [7]. Optimization of oxygen consumption-oxygen delivery relation has the goal of improving intraoperative patient status that contributes to a favorable postoperative evolution [6] [7]. In our hospital, goal-directed therapies are not yet routine generalized practice. It is time to reconsider integrating goal-directed therapies

**Table 3.** Patient with fatal outcome.

| Surgery                       | Age months | ASA score | Co-morbidities      | Intra-operative complications | Postoperative outcome                       | Delay of in-hospital mortality in days | Emergency | Transfusion |
|-------------------------------|------------|-----------|---------------------|-------------------------------|---|--|-----------|-------------|
| Posterior fossa decompression | 85         | 5         | Sickle cell disease | 0                             | Multiple organ failure and pulmonary sepsis | 7                                      | Yes       | Yes         |

**Table 4.** Outcomes per surgery.

| Surgery  | Number of patients | Intra-operative anaphylaxis | Intra-operative difficult intubation | Intraoperative hemorrhagic shock | Postoperative cardio-circulatory failure | Postoperative endocrinal failure | Postoperative miscellaneous | Postoperative multiple organ failure | Postoperative neurologic failure | Postoperative abdominal sepsis | Postoperative pulmonary sepsis | Postoperative septicemia | Postoperative urinary sepsis | Re-operation | In-hospital mortality | Transfusion |
|--|--------------------|-----------------------------|--------------------------------------|----------------------------------|--|----------------------------------|-----------------------------|--------------------------------------|----------------------------------|--------------------------------|--------------------------------|--------------------------|------------------------------|--------------|-----------------------|-------------|
| Basal skull schwannoma   | 3                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Brainstem lesion resection   | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Cerebral aneurysm/Cerebral arterio-venous malformation angioembolization | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 0                              | 0                        | 1                            | 0            | 0                     | 1           |
| Cerebral cavernoma   | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 0           |
| Chiari's malformation  | 4                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 0           |
| Craniosynostosis   | 3                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Epileptogenic lesion resection   | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Femoral osteotomy  | 6                  | 0                           | 0                                    | 1                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 3           |
| Femoral prosthesis   | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Hepatic tumor  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Interscapular thoracic desarticulation                                   | 2                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 2           |
| Intestinal resection   | 5                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 0           |
| Intracerebral tumor resection  | 6                  | 1                           | 0                                    | 0                                | 0  | 1                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Knee prosthesis  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Laparotomy for volvulus  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Limb tumor resection   | 8                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 4           |
| Liver transplantation  | 3                  | 0                           | 0                                    | 0                                | 1  | 0                                | 1                           | 0                                    | 0                                | 1                              | 0                              | 0                        | 0                            | 1            | 0                     | 3           |
| Neuroblastoma  | 1                  | 0                           | 1                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Orbital tumor  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 0           |
| Pelvic osteotomy   | 4                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 3           |
| Pelvic tumor   | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 0           |
| Posterior fossa decompression  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 1                                    | 0                                | 0                              | 1                              | 0                        | 0                            | 0            | 1                     | 1           |
| Renal transplantation  | 4                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 1                            | 0            | 0                     | 2           |
| Scoliosis  | 23                 | 0                           | 0                                    | 1                                | 1  | 0                                | 0                           | 0                                    | 3                                | 0                              | 0                              | 2                        | 0                            | 1            | 0                     | 9           |
| Splenectomy  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 0                                | 0                              | 0                              | 0                        | 0                            | 0            | 0                     | 1           |
| Ventriculostomy  | 1                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 1                              | 0                        | 0                            | 0            | 0                     | 1           |
| Vertebral laminectomy/Arthrodesis  | 3                  | 0                           | 0                                    | 0                                | 0  | 0                                | 0                           | 0                                    | 1                                | 0                              | 0                              | 1                        | 0                            | 1            | 0                     | 2           |

**Table 5.** Co-morbidities.

| Co-morbidity   | Number of cases (%) |
|--|---------------------|
| Arachnoid cyst   | 1 (1.1)             |
| Arthritis  | 4 (4.5)             |
| Bronchodysplasia sequelae  | 1 (1.1)             |
| Cancer   | 2 (2.2)             |
| Cerebral aneurysm/Cerebral arterio-venous malformation, Pulmonary hypertension | 2 (2.2)             |
| Cerebral anoxic lesions  | 4 (4.5)             |
| Chiari's malformation  | 2 (2.2)             |
| Chronic renal failure  | 4 (4.5)             |
| Convulsive encephalopathy  | 1 (1.1)             |
| Crohn's disease  | 1 (1.1)             |
| Epilepsy   | 2 (2.2)             |
| Ewing's sarcoma  | 5 (5.7)             |
| Extradural hematoma  | 1 (1.1)             |
| Gorlin's syndrome  | 1 (1.1)             |
| Hepatic failure  | 4 (4.5)             |
| Intestinal pseudo-occlusion  | 1 (1.1)             |
| Intracerebral tumor  | 7 (7.9)             |
| Klippel-Feil Syndrome  | 1 (1.1)             |
| Larsen syndrome  | 1 (1.1)             |
| Morquio syndrome   | 1 (1.1)             |
| Myelomeningocele   | 2 (2.2)             |
| Necrotizing enterocolitis sequelae   | 1 (1.1)             |
| Neurofibromatosis  | 3 (3.4)             |
| Pierre Robin syndrome  | 1 (1.1)             |
| Polymalformation syndrome  | 4 (4.5)             |
| Polytrauma   | 2 (2.2)             |
| Psychomotor deficiency   | 5 (5.7)             |
| Rachitism  | 1 (1.1)             |
| Sarcoidosis  | 1 (1.1)             |
| Sickle cell disease  | 1 (1.1)             |
| Crouzon syndrome   | 1 (1.1)             |

in intraoperative patient management in high-risk patients and surgery to improve postoperative outcomes.

## Author's Contributions

Claudine Kumba conceptualized and designed the study and drafted the initial manuscript. She designed the data collection instruments, collected data, carried out initial and final analyses.

## Conflicts of Interest

The author declared no conflicts of interest regarding the publication of this paper.

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