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Effectiveness and Complications of Surgical Drainage in Pediatric Surgery: A Literature Review

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Abstract: The use of surgical drainage is a common adjunctive procedure in various pediatric surgeries. However, its effectiveness and associated risks remain a subject of debate, particularly due to variations in drain types, surgical techniques, and the unique characteristics of pediatric patients. This study aimed to evaluate the effectiveness and complications of surgical drainage in various pediatric surgical procedures based on the most recent literature. This narrative literature review was compiled from articles published in the last 10 years (2015–2025), sourced from reputable databases such as PubMed, Cochrane, EBSCO, and Google Scholar. Inclusion criteria encompassed studies involving pediatric patients aged 0–18 years undergoing thoracic, abdominal, ocular, or spinal surgeries, addressing the use of surgical drainage either as a primary intervention or in comparison to non-drain approaches. A total of 20 studies were analyzed in this review. Overall, drainage proved most effective in thoracic and ocular surgeries. In thoracic surgery, devices such as the Thopaz digital drain shortened hospital stays, accelerated recovery, and reduced the number of postoperative radiographs. In ocular surgery, glaucoma drainage devices (GDD) effectively controlled intraocular pressure (IOP) and reduced the need for re-intervention. Conversely, in abdominal surgeries such as appendectomy and laparoscopic pyeloplasty, as well as spinal surgeries, drainage did not confer significant clinical benefits in reducing complications or accelerating recovery. Complications in thoracic surgery included minimal risks such as prolonged air leaks and empyema; in ocular surgery, hypotony, bleb encapsulation, infection, and tube revision were most common; in abdominal surgery, complications included infection, intra-abdominal abscess, bowel obstruction, iatrogenic leaks, peritonitis, and hernia; while in spinal surgery, complications consisted of superficial infections, wound dehiscence, neurological deficits, and hematoma. In conclusion, surgical drainage is most effective in thoracic and ocular surgeries in terms of success rate, accelerated recovery, and reduced length of hospital stay. However, in abdominal and spinal surgeries, drainage offers no significant clinical benefit and carries potential risks of complications.
Keywords: surgical drainage; complications; effectiveness; pediatric surgery

INTRODUCTION

Pediatric surgery plays a vital role in managing various complex medical conditions, such as infections, congenital malformations, and tumors, which often require special approaches due to the physiological and immunological differences between children and adults.[1] Optimal postoperative management is essential for successful surgical outcomes in this population, including the utilization of surgical drainage as an important adjunctive procedure.

Surgical drainage functions to remove excess fluids such as blood, exudate, or pus from the surgical site, thereby preventing complications such as fluid accumulation, abscess formation, or wound infection.[2] The types of drains used vary widely depending on the surgical procedure, for example, the Thopaz system in thoracic surgery, peritoneal and external urinary drains in abdominal surgery, and glaucoma drainage devices (GDD) such as Ahmed, Baerveldt, and AADI in ocular surgery.[3–5] However, the effectiveness of drainage in pediatric patients remains controversial. Several studies have shown that drains can accelerate recovery and reduce hospital stays, as seen in cases such as pulmonary lobectomy or glaucoma surgery.[2,5] In contrast, other studies have found that in certain procedures, such as appendectomy, the use of drains offers no significant benefit and may even increase the risk of complications such as infection or bowel obstruction.[6,7]

Furthermore, there are currently no consistent clinical guidelines regarding the indications for drainage use based on surgical type and pediatric patient conditions. Consequently, many clinical decisions rely on surgeon preference or hospital policy.[8] Therefore, this literature review is essential to evaluate the effectiveness and complications of surgical drainage across various pediatric surgical procedures, aiming to provide a comprehensive overview of the latest literature to assist clinicians in making evidence-based decisions regarding the use of surgical drainage in pediatric patients.

METHODS

This literature review was conducted using a narrative approach to describe and analyze scientific developments regarding the effectiveness and complications of surgical drainage in pediatric surgery. The literature was collected from reputable sources, including journals indexed in scientific databases such as Medline (PubMed), Cochrane, EBSCO, and Google Scholar, published within the last 10 years (2015–2025). The inclusion criteria comprised pediatric patients aged 0 to 18 years who underwent thoracic, abdominal, ocular, or spinal surgery in which drains were used, or studies comparing different types of drains, or comparing drainage with non-drain or other non-invasive interventions. The clinical outcomes or effectiveness measures assessed in the included studies encompassed length of hospital stay, duration of drain placement, recovery time, success rate, need for additional interventions, and reported complications. The findings are presented in a summary table, detailing the study type, population and clinical diagnosis, type of surgery, type of drain, clinical outcomes, and complications.

RESULTS

The studies included in this review involved sample sizes ranging from 11 to 372 pediatric and adolescent patients with a range of medical conditions, from neonates to adolescents. Thoracic surgery studies typically involved patients with pneumothorax or pulmonary malformations, aged 18 months to 17.2 years. Abdominal surgery included neonates with very low birth weight (VLBW) and necrotizing enterocolitis (NEC), as well as children with appendicitis, with a mean age of 7 to 9 years. Ocular surgery focused on children with refractory or congenital glaucoma, while spinal surgery addressed adolescents with idiopathic scoliosis.

Common thoracic procedures included pulmonary lobectomy and lung resection. Abdominal

surgeries commonly performed were laparoscopic appendectomy and pyeloplasty, while ocular surgery involved glaucoma drainage devices (GDD) such as the Ahmed Glaucoma Valve. Spinal surgery frequently involved posterior spinal fusion (PSF) and pedicle screw instrumentation. Drain types varied across surgeries namely digital drains (Thopaz) were used in thoracic surgery, peritoneal and external urinary drains in abdominal surgery, various GDDs in ocular surgery, and subfascial closed suction drains in spinal surgery.

Clinical outcomes varied by surgery type: thoracic outcomes included drain duration and air leak resolution; abdominal surgery assessed recovery from NEC, appendicitis complications, and hospital stay; ocular surgery focused on intraocular pressure (IOP) control and long-term success; spinal surgery evaluated blood loss, transfusion requirements, and infection rates.

DISCUSSION

Related to the effectiveness in thoracic surgery, the chest drainage, particularly digital systems like Thopaz, is highly effective in accelerating postoperative recovery. Pérez-Egido et al[3] reported shorter drain removal times in children with pulmonary malformations or metastases, though hospital stay was not significantly different. Costa Jr et al[9] found Thopaz reduced drainage volume, shortened drain duration, and improved air leak interpretation after lobectomy or segmentectomy. Moreover, Frediani et al[2] demonstrated significant reductions in drainage duration, hospital stay, and postoperative radiographs in pediatric pneumothorax compared to Pleurevac. Vasconcelos-Castro et al[10] reported average drain duration and hospital stay of approximately four days in primary spontaneous pneumothorax. In abdominal surgery, the effectiveness of postoperative drainage depends on the condition and procedure. Shen et al[1] showed peritoneal drains in NEC neonates facilitated faster abdominal recovery and shorter hospital stays. Ghestem et al[4] reported safe and efficient use of external urinary drains after laparoscopic pyeloplasty, also shortening hospitalization. However, prophylactic drains in appendicitis often provide limited benefit. Castro et al[6] and David et al[7] found drains prolonged hospital stay, fasting, and medication needs. Gorter et al[8] showed non-drain strategies allowed faster recovery. Voglino et al[11] observed slower inflammatory marker resolution and longer stays with drains. Human et al[12] reported no significant differences in operative time or postoperative antibiotics, questioning prophylactic drain use. Meanwhile, in ocular surgery, glaucoma drainage devices (GDD) effectively reduce intraocular pressure (IOP) in refractory, congenital, and post-cataract glaucoma. Mandalos and Sung[13] reported significant IOP reduction in 69 eyes with Baerveldt and Molteno GDDs. Nazirova et al[14] found Glautex biodegradable drains superior to autoscleral drainage, with better IOP control, fewer repeat procedures, and avoidance of sharp postoperative IOP drops. Kaushik et al[5] also reported the AADI reduced IOP from 27.4 mmHg to ~14 mmHg over 18–24 months, with 91% and 82% success at 6 and 18–24 months. Chen et al[15] showed AGV reduced mean IOP by 13 mmHg over five years. Esfandiari et al[16] observed IOP decrease from 29.3 mmHg to 17.6 mmHg four years after AGV or BGI placement, with 72% success. Puthuran et al[17] reported AADI lowered IOP up to 55% within one year, with 77% success at two years. In case of spinal surgery, the benefit of subfascial closed suction drains in posterior spinal fusion (PSF) for adolescent idiopathic scoliosis is unclear. Helenius et al[18] found no significant differences in hemoglobin reduction or hospital stay in 90 adolescents. Ovadia et al[19] reported no differences in hospitalization, transfusions, or postoperative hemoglobin among 100 patients, though non-drain patients had slightly higher fever rates on day six. Meanwhile, Kochai and Erkorkmaz[20] observed that drains led to more wound oozing, larger hemoglobin decreases, and longer hospital stays.

In the case of complications in thoracic surgery, despite effectiveness, pulmonary lobectomy

and lung resection may cause prolonged air leaks, sometimes requiring extended drainage. Pérez-Egido et al[3] reported that Thopaz accelerated drain removal and reduced postoperative radiographs, but prolonged air leaks remained a challenge. Frediani et al[2] noted prolonged air leaks in 19.5% of Thopaz patients. Rare complications include empyema or pleural infection; Vasconcelos-Castro et al[10] reported one case of postoperative empyema despite reduced air leaks with Thopaz+. Meanwhile, in abdominal surgery, postoperative complications depend on procedure and patient condition. Shen et al[1] found peritoneal drains in NEC neonates were safe and reduced complications compared to conservative management. Ghestem et al[4] reported pyelonephritis and kidney stones after external urinary drains post-laparoscopic pyeloplasty. In appendicitis, drains often offer limited benefit, and Castro et al[6] found no difference in complication rates. Voglino et al[11] observed slightly higher infection in the drain group. Gorter et al[8] noted invasive drainage could cause recurrent abscesses or iatrogenic leakage. David et al[7] reported abscesses and reoperation despite drains. Moreover, Human et al[12] documented serious complications—peritonitis, intra-abdominal collections, wound sepsis—with 67% requiring relaparoscopy. In ocular surgery, GDDs effectively lower IOP but may cause hypotony, bleb encapsulation, infection, and tube revision. Mandalos and Sung[13] reported these complications, including endophthalmitis, without affecting long-term outcomes. Nazirova et al[14] found Glautex had a better complication profile than autoscleral drainage, with no hypotony and fewer events like hyphema or vascular detachment. Kaushik et al[5] observed minimal complications with AADI, with no tube erosion or infections. In contrast, Chen et al[15] reported higher AGV complications: tube revision (21.8%), cataract surgery (4.2%), tube exposure (8.3%). Esfandiari et al[16] noted hyphema (26.9%), tube-cornea touch, and choroidal effusion. Puthuran et al[17] found 35% of AADI patients experienced significant complications, including endophthalmitis and tube exposure. In spinal surgery, complications are generally mild to moderate, such as superficial infections, wound dehiscence, and occasional neurological deficits. Helenius et al[18] reported SSI in one patient with a drain and two without, plus one postoperative neurological deficit in the drain group. Ovadia et al[19] observed pneumonia in one non-drain patient, wound dehiscence in three patients (two without drains, one with), and superficial infections in two without drains. Kochai and Erkorkmaz[20] reported superficial infections in five drain patients and four non-drain patients, with no significant differences and no deep infections or hematomas.

The studies included in this review present several methodological limitations that warrant consideration. The majority were observational and retrospective single-center studies, which inherently limit the generalizability of findings and introduce potential bias. Variations in drain types, insertion techniques, and surgical procedures further complicate direct comparisons between studies. In addition, many studies had relatively small sample sizes, reducing the statistical power to detect significant differences in outcomes. Another limitation is that several studies did not assess long-term outcomes, particularly regarding the recurrence of complications, which could provide a more comprehensive understanding of the true benefits and risks of drainage in pediatric surgery.

CONCLUSION

In thoracic surgery, digital drains such as Thopaz effectively accelerate recovery, reduce hospital stay, and minimize postoperative radiographs, though complications like atelectasis and pneumonia may still occur. Percutaneous drainage with fibrinolytics is effective for pleural empyema, but recurrence is higher if fibrinolytics are omitted. In abdominal surgery, prophylactic drains in complicated or uncomplicated appendectomy provide limited benefit, may prolong recovery, and increase risks such as wound infection or bowel obstruction; however, peritoneal or

percutaneous drainage remains beneficial in specific cases like NEC or appendicular abscess. In ocular surgery, glaucoma drainage devices (AGV, Baerveldt, AADI) lower intraocular pressure in refractory or congenital glaucoma, though hypotony, tube infection, and tube exposure remain potential complications. In spinal surgery, especially posterior spinal fusion, subfascial closed suction drains show no significant clinical benefit, with superficial infections and wound dehiscence occurring at similar rates in both drain and non-drain groups.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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Table 1. Summary of Literature

No	Author & Year	Study Design	Population/ Samples	Type of Surgery	Type of Drain	Clinical Outcomes (Effectiveness)	Complications
Thoracic surgery							
1	Pérez-Egido et al, 2019[3]	Prospective Observational Study	26 pediatric patients with pulmonary mal-formations or pulmo-nary metastases, median age 18 months	Pulmonary lobectomy or lung resection	Digital drain (Thopaz) vs. conventional drain	Significantly faster drain removal in the Thopaz group (1.69 ± 0.6 vs. 5.38 ± 4 days). No significant difference in hospital length of stay. Significant reduction in postoperative radiographs in the Thopaz group (2.8±1.1 vs. 6.23±5.2).	No drain-related com-plications
2	Costa Jr et al, 2016[9]	Prospective Observational Study	11 children ≤14 years with recurrent infections, pulmo-nary malformations, and bronchiectasis, mean age 5.9±3.3 years	Lobectomy or segmentectomy	Digital Drain (Thopaz)	Mean hospital stay: 4.9±2.6 days; drain duration: 2.5±0.7 days; mean drainage volume: 270.4±166.7 mL. digital sys-tem facilitated post--operative decision-making by reducing errors in inter-pretation and management of air leaks.	Two cases (atelectasis, pneumonia)
3	Frediani et al. 2023[2]	Retrospective Observational Study	160 pediatric patients (mean age 10.45 years) with pneumothorax	Thoracotomy, thoracoscopy, lung resection, thoracic mass removal	Thopaz Digital System (Medela) vs. Pleurevac	Thopaz reduced drainage duration (10.64 vs. 16.87 days), accelerated recovery, shortened hospital stay (21.55 vs. 29.3 days), and decreased postoperative X-rays (4.29 vs. 8.41). All differences were significant.	Complications: prolonged air leak (19.5% Thopaz vs. 17.9% Pleurevac), post-operative pneumothorax after drain removal (4.82% vs. 7.6%); no statistically significant difference
4	Vasconcelos-Castro et al, 2023[10]	Retrospective Descriptive Study	17 procedures in 11 pediatric patients (median age 17.2 years) with primary spontaneous pneumothorax	Thoracoscopy + bleb/lung apex resection + pleurectomy or pleurodesis	Digital Drainage System (Thopaz+)	Mean chest drainage duration: 4 days; mean hospital stay: 4.5 days. After protocol change to target air leak <5 mL/min for 24 hrs, all patients managed successfully without recurrent complications.	2 recurrent pneumothorax cases before protocol change; 1 severe complication (empyema requiring lung decortication)
Abdominal surgery							
5	Shen et al, 2023[1]	Retrospective Cohort	102 VLBW neonates with stage II NEC	Initial non-ope-rative (peri-toneal drainage), possible conversion to laparotomy	Peritoneal drain vs exploratory lapa-rotomy vs conser-vative treatment (fasting, GI decompression, IV nutrition, antibiotics)	Peritoneal drain shortened fasting time, abdominal recovery, and hospital stay compared to conservative care	Lower risk, safer than conservative treatment

No	Author & Year	Study Design	Population/ Samples	Type of Surgery	Type of Drain	Clinical Outcomes (Effectiveness)	Complications
6	Ghestem et al, 2023[4]	Prospective, single-center	14 children, median age 10 years, with ureteropelvic junction syndrome	Transperitoneal laparoscopic pyeloplasty	External urinary drain (Blue stent via K-wire)	Quick placement (<5 min), safe, no drain migration, short hospital stay (2±1 days)	1 pyelonephritis (D8), 1 kidney stone (8 mm) managed with ESWL
7	Aneiros Castro et al, 2018[6]	Retrospective Study	192 pediatric perforated appendicitis (117 with drain, 75 without), mean age 7.7 years	Laparoscopic appendectomy	Prophylactic drain vs no drain	Drains did not reduce postoperative complications; associated with longer antibiotic and analgesic use, fasting, and hospital stay	No significant difference in intra-abdominal abscess, wound infection, or bowel obstruction
8	Voglino et al, 2024[11]	Retrospective, single-center	186 children with complicated appendicitis	Laparoscopic appendectomy	Peritoneal drain vs no drain	Drain group had longer CRP normalization (6 days [IQR 4–9.5] vs 8 days [7–12], P=0.0222) and longer hospital stay (9 days [IQR 6–11] vs 6 days [IQR 4–8], P=0.0002)	Slightly higher infection complications; not statistically significant
9	Gorter et al, 2016[8]	Retrospective Cohort + Literature Review	372 pediatric appendectomy patients (25 developed post-appendectomy abscess)	Laparoscopic or open appendectomy	Non-invasive vs invasive (percutaneous or surgical drainage)	Non-invasive successful in 69% of patients vs 67% with invasive; non-invasive associated with shorter hospital stay	Complications after invasive drainage: recurrent abscess, iatrogenic leak, small bowel obstruction
10	David et al, 2019[7]	Retrospective Study	120 children undergoing laparoscopic appendectomy for uncomplicated appendicitis	Laparoscopic appendectomy	Prophylactic drain vs no drain	Prophylactic drain did not reduce postoperative complications; prolonged recovery, hospital stay, and analgesic need	Complications: intra-abdominal abscess (1 per group), omental evagination, reoperation for abscess drainage
11	Human, 2022[12]	Prospective, Randomized	34 children with complicated appendicitis, mean age 9 years	Laparoscopic appendectomy	Peritoneal drain vs no drain	No significant difference in outcomes between groups; patients with generalized pus more likely to have complications	Complications: intra-abdominal collections (IAC), peritonitis, wound sepsis; re-laparoscopy required in 67% with IAC
Occular surgery							
12	Mandalos, Sung, 2017[13]	Retrospective Study	52 children (69 eyes) with refractory glaucoma	Glaucoma drainage device implantation	Baerveldt and Molteno GDD	Significant IOP reduction; stable pressure control in most cases	Hypotony, bleb encapsulation, endophthalmitis, and tube repositioning occurred more frequently
13	Nazirova et al, 2020[14]	Prospective Descriptive Study	47 children (50 eyes) with congenital glaucoma	Glaucoma surgery	Glautex biodegradable drain (Group 2) vs. autoscleral drainage (Group 1)	Group 2 (Glautex) showed significant IOP reduction, decreased need for reoperation, and avoided sharp postoperative IOP drops	Hypotony in 14% of Group 1, none in Group 2; other complications: hyphema (13% in Group 2), vascular detachment (6% in Group

							1)
14	Kaushik et al, 2017[5]	Retrospective Study	34 eyes from 31 children with refractory glaucoma	AADI implantation	AADI (glaucoma drainage device)	Success rate: 91% (6 months), 82% (18–24 months); IOP reduced from 27.4 mmHg to ~14 mmHg	Minimal complications; no tube erosion or infection
15	Chen et al, 2015[15]	Retrospective Study (1999–2012)	119 eyes from 89 children <18 years with primary glaucoma	Ahmed Glaucoma Valve implantation	Valved GDD (silicone & polypropylene)	Mean IOP reduction of 13 mmHg at 5 years; success rates: 55% (1 GDD), 52.8% (2 GDD) over 5 years	Tube revision (21.8%), cataract (4.2% requiring surgery), strabismus (2.5%), tube exposure (8.3%), removal of second GDD
16	Esfandiari et al, 2019[16]	Retrospective Study	28 eyes from 28 children with glaucoma following cataract surgery (GFCS)	AGV or BGI implantation	Ahmed Glaucoma Valve (AGV), Baerveldt Glaucoma Implant (BGI)	IOP decreased from 29.3 mmHg to 17.6 mmHg at 4-year follow-up; success rate: 72%	Hyphema (26.9%), choroidal effusion (1 case), corneal decompensation (1), tube exposure (1), tube-cornea touch (1), early hypotony (1)
17	Puthuran et al, 2019[17]	Retrospective Study	101 children (mean age 10.4 years) with refractory glaucoma	AADI implantation for refractory glaucoma	AADI (non-valved aqueous drainage implant)	IOP decreased by 55% within 1 year; success rates: 84% (1 year), 77% (2 years)	35% had complications (corneal touch, tube retraction, tube exposure, endophthalmitis)
Spinal surgery							
18	Helenius et al, 2022[18]	Multicenter Randomized Controlled Trial	90 adolescents with idiopathic scoliosis	Pedicle screw instrumentation	Subfascial closed suction drain vs. no drain	No difference in hemoglobin reduction; patients without drains required 30% more opioids within 48 hours	Surgical site infection (SSI): 2 in no-drain group, 1 in drain group; 1 postoperative neurological deficit in drain group
19	Ovadia et al, 2018[19]	Prospective Randomized Controlled Study	100 adolescents (ages 11–18) with adolescent idiopathic scoliosis (AIS)	Posterior spinal fusion (PSF)	Subfascial closed suction drain vs. no drain	Hospital stay similar (6 days); fever higher in no-drain group on day 6 (p=0.017); no significant difference in hemoglobin, hematocrit, or transfusion rates	Complications: 1 pneumonia (no-drain group), 3 wound dehiscence (2 no-drain, 1 drain), 2 superficial infections (no-drain); no deep infections, no reoperations
20	Kochai, Erkorkmaz, 2019[20]	Retrospective Study	52 adolescents (median age 15 years) with idiopathic scoliosis	Posterior spinal surgery	Subfascial closed suction drain (Group A) vs. no drain (Group B)	Wound drainage higher in drain group; wound oozing more frequent in Group A; lower postoperative hemoglobin in Group A; higher transfusion rates and longer hospital stay in Group A	Superficial infections: 5 in drain group, 4 in no-drain group; no hematoma or deep wound infections