

History of pediatric surgical innovation and its course in the age of Evidence Based Medicine

Ewa Bućko, Patrycja Sosnowska-Sienkiewicz, Przemysław Mańkowski

Department of Pediatric Surgery, Traumatology and Urology, Poznan University of Medical Sciences

Abstract. The history of pediatric surgery is the history of constant innovation. The methods and standards of innovation in medicine have changed significantly over time. The beginning of surgery based its discovery on experimentation and observation. It was always intertwined with the history of general surgery. For a long time, we observed the individualistic approach to innovation. However, as we enter the evidence-based era of medicine, the innovations in pediatric surgery change and adapt to fit into the new paradigm. This paper aims to describe the history of pediatric surgery from its early beginnings to the current times. It describes the changing approach to pediatric patients, that differs from the adult and shows the connection between pediatric and general surgery and the history of its separation. It also illustrates the shift between an individualistic approach to medicine and more study-based medicine and tries to show the direction of future development.

Key words: pediatric surgery, history of medicine, evidence based medicine

Introduction

Innovation in surgery is defined as “a new or modified surgical procedure that differs from currently accepted local practice, the outcomes of which have not been described, and which may pose a potential risk to the patient” (1).

The history of pediatric surgery is the history of constant innovation. From the very beginning doctors have looked for the tools to improve the care of their patients. However, throughout history, the ways of developing those methods and the way of implementing them changed significantly, as did the approach to modernization in medicine.

The aim of this paper is to present the development of methods used in pediatric surgery and analyze the pattern of innovation throughout medical history.

History

The beginnings

The history of pediatric surgery was always intertwined with the general surgery of adults. The first healers did not consider the age of the patients, as they primarily focused on treating traumas, such as wounds or foreign body infiltration, but also fracture repositions and abscess drainages (2).

The oldest known depiction of surgery is circumcision performed on a teenage boy in 2400 B.C.E. in Egypt. Though the age of the patient is not explicitly given we can assume that he is a child (3). In the same time surgical procedures involving circumcision, sterilization and orchidectomy were popular in Jewish and later Muslim community, Rome, China, and North Africa – but they're popularity

was mostly based on its religious and cultural significance (2,4).

Many of the congenital defects for a long time were perceived as unfixable or even treated as a monstrosity (5). The Torah and Talmud contain a list of congenital malformations that made a person unfit for service in the temple such as hypospadias, undescended testis, or limb deformity (6). Soranus, a healer practicing in Ancient Rome in the first century C.E., described the symptoms of an ineligible child that should be discarded after birth due to its deficits (7, 8). Only some of the congenital issues – for example short anal atresia – were treated with limited success (6).

In general, the first approach to pediatric surgical problems was based predominantly on observation mixed with cultural and religious beliefs, that might greatly influence the way of treatment. The same methods of treatment were used regarding the age of the patient (2,3,6).

The exception to the rule was the medical practice in Ancient India in the book Sushruta Samhita, that devotes the entire section solely to pediatric patients under the age of 16 years old, with descriptions of embryogenesis, the natural disease progress and the differences between techniques in pediatric and adult surgery during the same procedures such as removal of urinary stones (9,10).

Later, in ancient Greece and Rome healers such as Hippocrates or Celsus continued to observe the difference between adult and pediatric patients, but they did not describe the difference in surgical techniques regarding the age of the patients. They were however treating the problems typically associated with pediatric population, such as intussusception, umbilical hernias or club foot (2, 11, 12).

Times of slow development

Unfortunately, with the passage of time and the growing influence of the catholic church, the use of medical knowledge in Europe was restricted. The center of scientific development moved to the Arabian peninsula and medicine was one of the points of interest for many Arabic scholars (2). The one who extended our knowledge of pediatric surgery was a 10th-century practitioner, Albucasis. In his book “On Surgery and

Instruments” he recommends a wide use of cautery. He specifically mentions children in the procedure of hernia cauterization. That was supposed to create a scar, protecting from the recurrence of previously reduced hernia. He was treating obstructed urinary meatus and performed litotripsies, all of that considering different sets of tools for his smaller patients (2).

In the 11th century Constantin the African brought the surgical knowledge from Arabic countries back to Europe, unfortunately once more forgetting the distinction between pediatric and adult medicine. Surgical knowledge was also treated as a lower form of medicine and in huge part forbidden to practice in universities (2). One of the exceptions to that rule was Theodoric, who noticed that displaced pediatric fractures have a bigger tendency to correct themselves due to the continuous growth of the patient (14). Later, Yperman devoted a part of his book *La Chirurgie* to treating specifically pediatric hernia. However, these individuals were the brave exception from the general rule (2).

In the 16th century, with the slow rebirth of surgical skills, based hugely on rediscovering the human anatomy, more surgeons could again divide their attention between children and adults. To that group, we can include Ambroise Paré - the man known mostly for his practice in the army, who also practiced lithotomies and, mostly conservative treatment of club foot (15). Another surgeon treating both adults and children, regarding of their gender, was Pierre Franco, famous for his hernia surgeries. The technique did not vary regarding the patients' age. He did however surgically approach inborn defects - like cleft palate or additional digits. He also gives us the first documented description of removing the bladder stone by suprapubic incision, which was done in a 2-year-old patient (16). Another one was Johannes Fatio, the surgeon who operated also on umbilical hernias, and hypospadias, and, as the first surgeon in history, documented the case of conjoined twin separation (2). The differences between pediatric and adult patients got more and more noticed. In the 18th century, Cheseldon was writing about differences in bone structure between adults and infants (17).

The biggest development in pediatric surgery occurred in the 19th and 20th centuries. It was in large

part thanks to the development of anesthesia and the practice of antiseptics.

It is worth noticing that in the case of the antiseptics the first published case of the patient treated by Lister with carbolic acid as an antiseptic was an 11-year-old boy with a compound leg fracture. In fact, 4 of the 11 original patients in the study of treating fractures with that method were children. In the study of abscesses and infected joints treated with carbolic acid two of the patients were children (2,18). It shows us that pediatric surgery was not distinctive and also not excluded from the innovations of the 19th century.

The society created hospitals devoted solely to pediatric patients (like The Hospital des Enfants Malades started in 1802 in France) (2). The focus on predominantly pediatric patients resulted in an abundance of pediatric literature, including the first surgical compendium devoted only to pediatric surgery, named *Surgical Diseases of Infants and Children* 1873, written by Paul Greusant from the hospital mentioned before (2). Previously, in 1860, Athol Johnson, an English physician published a series of articles devoted to pediatric surgery in the esteemed *British Medical Journal* (19). On the other hand, the first American book for surgeons interested in pediatrics - *The Surgery of Childhood* by doctor De Forrest Willard recommended that hernias would be operated by Halsted method or Bassini methods, both of which were developed on the adult patients. (20).

Birth of pediatric surgery as specialty

In the 20th century trend to have surgical professionals devoted solely to pediatric patients got stronger. This is the period where we observe doctors taking care predominantly of children - as an example we can mention Dr Vaclav Kafka from Czechoslovakia or Gertrude Herzfeld from Scotland (2, 21). One of the most famous representants of the new discipline was doctor William Ladd. After the famous Halifax catastrophe in 1917, dr Ladd devoted his career to pediatric surgery. In 1927 he became a chief of surgery in Boston Children's Hospital devoting the department to help only pediatric patients. Working there, he described techniques for treating pylorostenosis and

intussusception, he also famously described the correction of intestinal malrotation (21-23). But though fighting for recognition for the specialty, dr Ladd recognized its firm connection to the entire surgical field. As he writes in the preface to the book *Abdominal Surgery of Infancy and Childhood*, which he wrote together with dr Gross he states: "This does not imply that Pediatric Surgery should always be set apart as a separate specialty, but it does indicate that infants and children can obtain improved surgical care if an appropriate number of men in each community will take a particular interest in this field and give it the attention which it rightfully deserves" (24).

After the retirement of dr Ladd in 1945 the department was led by dr Robert Gross and became a center for the development of pediatric surgery, training new specialists, and spreading new knowledge. In 1948, after the active persuasion from Herbert Coe, one of the graduates of the Boston program and pediatric surgeon, the American Academy of Pediatrics agreed to form its own surgical section, therefore making a place for exchanging ideas (21-23).

In the same time in United Kingdom the discipline of pediatric surgery was largely benefiting from work of dr Denis Brown. In 1928 he published his technique for safe and effective tonsillectomies, in 1931 he wrote a book about treatment of mechanical deformation of congenital malformation. He also contributed significantly in field of pediatric urology as well as developed the technique for pyloromyotomy (25)

From that moment the field of pediatric surgery noticed a significant emancipation from its general surgery roots. The emphasis that surgeons put on problems specific to pediatric surgery gave us many publications. *The Surgery of Infancy and Childhood* published by Robert Gross in 1953, describes the surgical approach to inborn conditions like esophageal atresia or enterogenic cysts (26). The surviving ratio of patients with inborn pediatric diseases such as intestinal atresia improved after the introduction of pediatric surgery as a separate discipline, which in return increased the trust of general surgeons and pediatricians, who at first, were unlikely to accept the new restrictive approach (21). In this way, pediatric surgery proved to be an effective way to improve patient care. This holds true to this day, as proven in the paper by Shah

et al. who claim that pediatric patients who underwent emergency surgeries made by general surgeons had a higher chance of complications and prolonged hospital stay compared to the patients operated on by pediatric surgeons (27).

However pediatric surgery still benefited from the discoveries made in the fields of general surgery. The new idea of administration of intravenous fluid was first used in 1923 by Rudolph Matas on adult patients with abdominal sepsis (28). The method was recognized as useful by pediatric surgeons, but the application was much more difficult, as the caliber of veins in pediatric patients is much smaller and the vessels got constantly punctured by the metal needle. It was not until 1950 that the plastic cannula was introduced to effectively treat patients with fluid therapy (29). That example clearly shows that though the achievements in general surgery were great inspirations, they not always could be copied to the smaller patients.

Challenges of the present

As we approach the current times pediatric surgery has its firm place in the medical landscape and it keeps developing as a discipline of its own. However, the ways of perfecting the discipline changed significantly since the times of Hippocrates, Albucasis, and even Ladd. The medical field tries to base its methods of treatment not only on personal experience and observation but predominantly on evidence-based medicine. We entered the era of scientific studies and research.

That poses a unique challenge for pediatric surgery, as the method of research cannot be simply copied from other medical fields. First of all - there is a limited number of patients with pediatric surgical disease which limits the experience of one surgical center. Secondly, the nature of surgical work very often prohibits the surgeon from conducting a double-blind study (30). Another problem is the extensive legal regulation, that limits the number of studies. Of course, legal regulations have to be implemented to ensure the safety of the patients. On the other hand, the complicated and convoluted process of research in many countries discourages young surgeons from pursuing that career path (31).

These factors translate to the numbers of research from the pediatric surgical field. In 1999 only 0,3% of pediatric studies were classified as prospective, randomized control studies and 1,48% as prospective studies (32). The number didn't change significantly over the ten years and remained less than 2% in 2010 (33). More current data were not available at the time of publication of this paper.

Pediatric surgery still has its major part in development of the surgical discipline. However it is often forced to use the knowledge based on extrapolation from general surgery (34). This, as we know, poses several problems. First of all, anatomically and physiologically the populations of patients are very different. Every pediatric surgeon knows the saying "The child is not a small adult". Knowing that, in extrapolating the results we risk making the mistake and endangering our patients (32).

Secondly, we face technological obstacles - not all the equipment used in adult surgery is applicable in pediatric surgery. That was already presented in the case of intravenous access but holds true to other topics - for example, laparoscopic and thoracoscopic techniques. Development of such started in the adult population, but gained its significance after the improvement of the quality of visualization. When the first appendectomy in an adult patient was performed in 1982 and the first cholecystectomy in 1983, many pediatric surgeons did not see the benefits of the method but saw a lot of its limitations. It took us a few more years and the successful performance of Nissen fundoplication in 1991 to gain trust in laparoscopy. Now we see many benefits from the widespread use of minimally invasive technique in appendectomy, Nissen fundoplication, and other surgical approaches (35).

The critique for a dismissive way of treating research studies might also be applied to the non-surgical aspect of pediatric surgery. The best example of that would be probably Enhanced Recovery After Surgery (ERAS) protocols. The perioperative care is a main focus of the ERAS study group started in 2001. Their studies aim to improve the surgical outcomes outside of an improvement of the surgical technique. Since the group's creation, it provided a list of perioperative protocols applied in various surgical fields such as colorectal surgery, urology, gynecology, and many

others (36). Currently, there are 34 ERAS protocols available on the website. However from all the resources, only one applies directly to pediatric surgery – a protocol of Perioperative Care in Neonatal Intestinal Surgery created in 2020. As stated in the paper itself, articles used in the creation of the recommendation had relatively low-quality evidence. Hence from 17 recommendations given by the protocol, only 8 are rated as strong (37).

In the same time, there is a noticeable influence of pediatric surgery on the treatment of the adult population. The extracorporeal membrane oxygenation (ECMO) was pioneered by dr Robert Bartlett and his colleagues in 1975 for treating pulmonary hypertension in newborns. Since then, the method proved its usefulness in many cardiac and respiratory diseases such as acute respiratory failures, myocarditis or congenital heart defects and it got adapted for an adult population, being widely used both for respiratory and cardiac failure (38–40).

The other field that benefited from experience in pediatric surgery is genital reconstructions. Many adult surgeons address the problem of penoplasty and urethroplasty using the techniques perfected by their peers during the treatment of hypospadias and urethral reconstructions (41).

In his editorial comment in 1968 Doctor Shirkey was afraid that extensive limitation of studies would cause children and infants to become “Therapeutic Orphans” – meaning patients with not enough medical care that was previously tested and medically proven. It is debatable if his statement holds true in the year 2023 (42). However the need for continues development of pediatric surgery as a discipline is noticeable.

Conclusion

Pediatric surgery was a part of surgical practice from its very beginning. Its first development was based on observation and personal practice. For a big part of its history, it was nearly inseparable from the surgery of adults. The way of individual innovation and experimentation with different methods of surgical treatment accompanied the development of different surgical techniques. However now, as the

specialty separated itself from general surgery and we enter the age of evidence-based medicine, there is a time for pediatric surgery to once again, adapt to its own challenges. There is a necessity for creating multicenter, prospective research based solely on pediatric patients. The techniques used in general surgery might be an inspiration and motivation for the development of pediatric surgery, however, they cannot be blindly transferred without the proper research. In the same time progress made in the field of pediatric surgery may be helpful in developing other medical disciplines and lead to continuous innovation. As was written by dr Mark Davenport “The history of the development of pediatric surgery has been one of empiricism and individualism and the term ‘evidence-based medicine’ is an aspiration rather than a requirement in this specialty (35)”. It is up to us to change it and let pediatric surgery continue on its path to innovation.

References

1. Biffi WL, Spain DA, Reitsma AM, et al. Responsible development and application of surgical innovations: a position statement of the Society of University Surgeons. *J Am Coll Surg* 2008; 206(6):1204–9.
2. Raffensperger JG. *Children’s surgery: a worldwide history*. Jefferson: McFarland; 2014.
3. Nunn, JF. *Ancient Egyptian Medicine*. Norman: University of Oklahoma Press; 1996
4. Gollaher D. *Circumcision: A History Of The World’s Most Controversial Surgery*. New York: Basic Books; 2001.
5. Löwy I. *Imperfect Pregnancies: A History of Birth Defects and Prenatal Diagnosis*. Baltimore: John Hopkins University Press; 2017
6. Jona J. *Biblical and Talmudic Accounts of Pediatric Conditions, Malformations and Disease, at Children’s surgery: a worldwide history*. Jefferson: McFarland; 2014.
7. Soranus. *How to Recognize the Newborn That Is Worth Rearing*. In *Soranus Gynecology*. Johns Hopkins University Press, 1991. p. 79
8. Kelly K. *The History of Medicine. Early Civilization. Prehistoric Times To 500 C.E.* New York: Ferguson Publishing Company; 2010.
9. Bhisagratna K.K.L. *An English Translation of Sushruta Samhita based on Original Sanskrit Text*, College Square Calcutta; 1907
10. Raveenthiran V. *Pediatric Surgery in Antient India In Raffensperger, J.G. Children’s surgery: a worldwide history*. McFarland, 2014. p 20-24
11. Jones WHS. *Hippocrates*. Cambridge: Harvard University Press; 1957

12. Spencer WG. *Celsus. De Medicina*. Cambridge: Harvard University Press; 1971
13. Spink MS, Lewis GL. *Albucasis. On Surgery and Instruments, A Definitive Edition of Arabic Text with English Translation and Commentary*. London: The Wellcome Institute of The History of Medicine; 1973
14. Campbell E, Colton J. *The surgery of Theodoric A.D. 1267*. New York: Appleton Century Crofts; 1960
15. Goyal P, Williams A. *Ambroise Pare In: Raffensperger, J.G. Children's surgery: a worldwide history*. McFarland, 2014. p 68-72
16. Franco P, Nicause E, Rosenman LD. *The Surgery of Pierre Franco: Of Turriers in Provence. Written in 1561*. Bloomington: XLibris Corporation; 2006
17. Kompanje EJ. The first successful separation of conjoined twins in 1689: some additions and corrections. *Twin Res* 2004; 7(6):537-41.
18. Lister J. *The Collected Papers of Joseph Baron Lister*. Oxford: Calendron Press; 1859
19. Guersant P. *Surgical Diseases of Infants and Children*. London: Forgotten Books; 2017
20. Johnson AA. Lectures on the Surgery of Childhood. *Br Med J* 1860; 1(158):1-4.
21. Komorowski AL. History of the Inguinal Hernia Repair. In: Canonico S, editor. *Inguinal hernia*. London: Intech Open; 2014.
22. Kopp CE. A salute to pediatric surgery in Czechoslovakia. *Journal of Pediatric Surgery* 1968; 3(6):647-8
23. Bill H. William E. Ladd, M.D.: great pioneer of North American pediatric surgery. *Prog Pediatr Surg* 1986; 20:52-9
24. Grosfeld JL, O'Neil Jr J. History of Pediatric Surgery: A Brief Overview In: Coran A, Adzick S, Krummel T, Laberge J.M, Shamberger R, Caldamone A, *Pediatric Surgery 7th Edition*, Elsevier Inc., 2012. Chapter 1, 5-9
25. Nakayama DK. Sir Denis Browne, the father of modern pediatric surgery. *J Pediatr Surg* 2017; 53(3):576-9.
26. Ladd WE, Gross RE. *Abdominal Surgery of Infancy and Childhood*. Philadelphia: Saunders, 1948.
27. Gross RE. *The Surgery of Infancy and Childhood: Its Principles and Techniques*. Philadelphia: Saunders; 1953.
28. Shah AA, Shakoor A, Zogg CK, et al. Influence of subspecialty surgical care on outcomes for pediatric emergency general surgery patients in a low-middle income country. *Int J Surg* 2016; 29:12-8.
29. Zimmerman JJ, Strauss RH. History and current application of intravenous therapy in children. *Pediatric Emergency Care* 1989; 5(2):120-7.
30. Vaos G, Dimopoulou A, Zavras N. A Review of History and Challenges of Evidence-Based Pediatric Surgery. *J Invest Surg* 2022; 35(4):821-32.
31. Riskin DJ, Longaker MT, Krummel TM. The ethics of innovation in pediatric surgery. *Seminars in Pediatric Surgery* 2006; 15(4):319-23.
32. Hardin WD, Stylianos S, Lally KP. Evidence-based practice in pediatric surgery. *J Pediatr Surg* 1999; 34(5):908-13.
33. Ostlie DJ, St Peter SD. The current state of evidence-based pediatric surgery. *J Pediatr Surg*. 2010; 45(10):1940-6.
34. Krummel TM, Gertner M, Makower J, et al. Inventing our future: training the next generation of surgeon innovators. *Semin Pediatr Surg* 2006; 15(4):309-18.
35. Davenport M. Laparoscopic surgery in children. *Ann R Coll Surg Engl* 2003; 85(5):324-30.
36. Ljungqvist O, Young-Fadok T, Demartines N. The History of Enhanced Recovery After Surgery and the ERAS Society. *J Laparoendosc Adv Surg Tech A* 2017; 27(9):860-2.
37. Brindle ME, McDiarmid C, Short K, et al. Consensus Guidelines for Perioperative Care in Neonatal Intestinal Surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations. *World J Surg* 2020; 44(8):2482-92.
38. Bartlett RH, Roloff DW, Cornell RG, Andrews AF, Dillon PW, Zwischenberger JB. Extracorporeal Circulation in Neonatal Respiratory Failure: A Prospective Randomized Study. *Pediatrics* 1985; 76(4):479-87.
39. Jenks CL, Raman L, Dalton HJ. Pediatric Extracorporeal Membrane Oxygenation. *Critical Care Clinics* 2017; 33(4):825-41.
40. Maslach-Hubbard A. Extracorporeal membrane oxygenation for pediatric respiratory failure: History, development and current status *World Journal of Critical Care Medicine* 2013; 2(4):29.
41. Lambert SM, Snyder HM, Canning DA. The History of Hypospadias and Hypospadias Repairs. *Urology* 2011; 77(6):1277-83.
42. Shirkey H. Editorial comment: Therapeutic orphans. *The Journal of Pediatrics* 1968; 72(1):119-20.

Correspondence:

Ewa Bućko

Department of Pediatric Surgery, Traumatology and Urology,
Poznan University of Medical Sciences

E-mail: e.bucko37@gmail.com