Journal of Pediatric Surgery 59 (2024) 161642

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.sciencedirect.com/journal/journal-of-pediatric-surgery

Finnish Pediatric Surgery Hub – From Centralization to Collective Learning and Sharing of Expertise

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ARTICLE INFO

Article history:
Received 20 May 2024
Received in revised form
26 June 2024
Accepted 20 July 2024

Keywords:
Collaboration
Concentration of care
Network
Neonatal surgery

ABSTRACT

Aim of the study: Continuous surgical developments, growing awareness of patient representatives and limited health-care resources are pushing for innovative approaches to ensure equal high-quality pediatric surgical care. We aimed to describe early experiences and assess surgical safety of a novel nationwide pediatric surgery collaborative initiative.

Methods: In 2021, general pediatric surgeons representing all five independent university hospitals performing neonatal surgery in Finland initiated national collaboration, the Finnish pediatric surgery hub (FPSH), for sharing of surgical expertise and collective learning. For each case addressed by FPSH, place of care and surgical team were decided individually, and when deemed necessary, operations were performed in cooperation. Operations performed during 2021–2023 and associated early (<30 days) postoperative complications were analyzed according to Clavien-Madadi classification.

Results: Of the total 40 surgeries managed co-operatively by FPSH, 30 (75%) took place in local university hospitals and 10 in Helsinki University Hospital. There were 34 (85%) elective and 6 urgent cases, which were operated within median 1 (range, 1–3) days. Most frequent underlying diagnoses included anorectal malformations, esophageal atresia and Hirschsprung disease. Overall, 12 (30%) had any early postoperative complications, all Clavien-Madadi grade IIIB or lower, and five patients (13%) were reoperated. Rate or grade of complications was not associated with place of care. In addition to regular virtual case meetings, national care protocols and research projects were introduced.

Conclusion: These preliminary findings suggest that our national collaborative initiative, FPSH, not only provided practical and safe framework for sharing of surgical expertise but also for collective learning.

Level of Evidence: III.

1. Introduction

Continuous surgical developments with increasing sub-specialization, growing awareness of patient representatives and limited health-care resources are pushing for innovative approaches to ensure equal high-quality pediatric surgical care. Traditionally, concentration of care has been achieved by centralization whereby management of selected complex and rare conditions, such as biliary atresia, is confined to one or few national centers [1,2]. Although centralization has markedly improved outcomes of biliary atresia in England and Wales and Finland [3,4], it remains unclear to what extent concentration of care by centralization universally improves outcomes of other less critical pediatric and neonatal surgical conditions [5]. At national level, centralization may lead to decline of pediatric surgical skills outside the index center, predispose to dissension among pediatric surgical community and lead to new

Abbreviations: FPSH, Finnish pediatric surgery hub; ERNICA, European reference network for rare inherited congenital anomalies; ECMO, extracorporeal membrane oxygenation; EA, esophageal atresia; HUH, Helsinki University Hospital; KUH, Kuopio University Hospital; OUH, Oulu University Hospital; TAUH, Tampere University Hospital; TUH, Turku University Hospital.

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https://doi.org/10.1016/j.jpedsurg.2024.07.027

unexpected organizational problems, while endangering effective national care pathways and training [5–8]. For patients and their families, hospitalizations far away from home beyond the reach of their own support network are very problematic and may lead to increased overall costs [6].

Instead of traditional centralization, pediatric surgeons from all five Finnish university hospitals established national collaboration, the Finnish pediatric surgery hub (FPSH), to enable sharing of surgical expertise and promote collective learning in a country with an unequal distribution of a limited number of neonatal surgical patients, and by European scale relatively long travelling distances (Fig. 1). Aims of this study were to describe implementation of our novel mode of collaboration focusing on the hub's structure and working mechanics as well as operations performed and short-term postoperative complications during the first years 2021–2023. We hypothesized that the majority of general pediatric surgical patients can be safely operated at local hospitals within the framework of FPSH, promoting collective learning at national level.

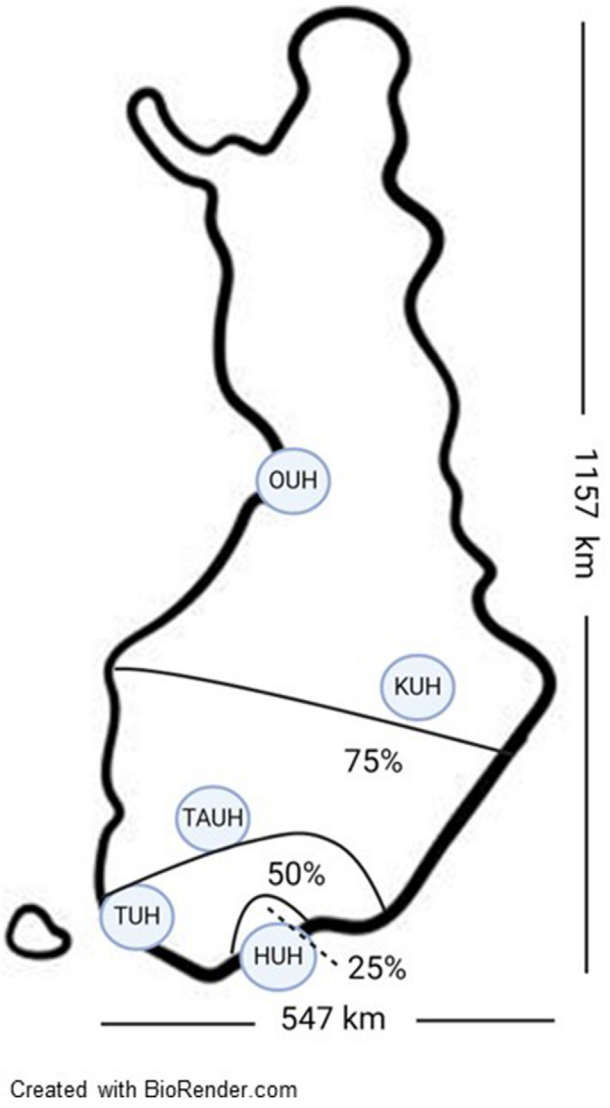

Fig. 1. Geographical dimensions and approximate population distribution of Finland. Percentages refer to the proportion of population living below each curve line. Helsinki University Hospital, HUH; Kuopio University Hospital, KUH; Oulu University Hospital, OUH, Tampere University Hospital, TAUH; Turku University Hospital, TUH.

2. Methods

2.1. Finnish pediatric surgery hub

In 2021, general pediatric surgeons representing all five independent university hospitals performing neonatal surgery in Finland initiated collaborative national consortium, FPSH, for dissemination of surgical expertise and collective learning. Any neonatal or general pediatric surgical conditions, excluding urological cases, could be addressed in FPSH, whereas pediatric cardiac surgery, all organ transplantations and hepato-pancreato-biliary surgery are nationally centralized to the New Children's Hospital, Helsinki University Hospital (HUH). Within FPSH, management of patients is coordinated by HUH (Fig. 2), the largest and only stand-alone university children's hospital in Finland, a full member of the European reference network for rare inherited congenital anomalies (ERNICA) and accredited for specialist training in pediatric surgery by the European board in pediatric surgery. HUH also runs nationwide extracorporeal membrane oxygenation (ECMO) service and feto-maternal center.

For each patient and operation, place of care and surgical team were decided individually. The place of surgical care was chosen based on emergency level, anticipated intensive care unit needs, potential postoperative problems and follow-up needs, surgical requirements, and bed availability.

The primary surgical team consisted of a local and HUH surgeon, who performed operations together. The primary operating surgeon for each surgery was decided based on the case complexity and surgeon's personal expertise and experience. Either HUH senior surgeons travelled to local hospitals or local surgeons travelled with a patient to HUH. Salary of travelling surgeons was covered by treating hospitals according to either personal or between-hospitals contracts.

For seamless communication among pediatric surgeons from the five participating hospitals, personal emails and, especially with urgent cases, direct cellphone conversations were used. Communication covered planning of operations, postoperative recovery, and any unanticipated problems as necessary. Regular monthly virtual case meetings were arranged for presentation of new patients, discussion of problematic cases and follow-up of operated patients.

National management and follow-up protocols for selected neonatal surgical conditions were introduced and research projects were launched involving participants from all five hospitals. Management and follow-up protocols were performed in cooperation with the Finnish association of pediatric surgeons to promote their efficient implementation.

2.2. Hub update in 2024

After initial experiences during 2021–2023, principles of FPSH activities were updated in early 2024 according to discussions in several web-based and one physical meeting with participants from all five hospitals. We collectively agreed to have weekly, instead of monthly virtual case meetings, where patients are prospectively recorded and presented using a shared structured form. We listed which new patients according to the underlying diagnosis are routinely presented in weekly case meetings by all centers. This updated list includes all neonatal surgical cases, tumors, inflammatory bowel disease, hepato-pancreato-biliary cases, and short bowel syndrome. We also specified the patients who should be operated at HUH due to special surgical and/or intensive care demands. Currently, patients with type A or B EA, esophageal reconstructions and re-operations, airway surgery, near total or total colonic aganglionosis, complex anorectal malformations, hepato-pancreato-biliary surgery excluding gallstone disease, autologous short bowel syndrome surgery and congenital diaphragmatic

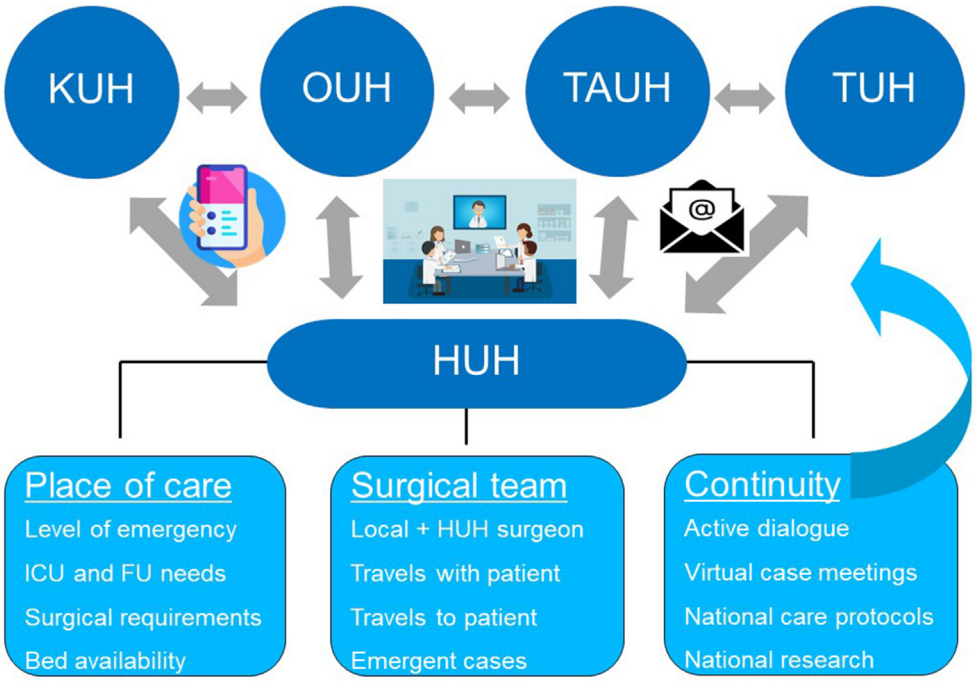

Fig. 2. Organization of the Finnish pediatric surgical hub. Place of care and surgical team were decided individually for each patient and operation. Operations were performed jointly by local and Helsinki University Hospital (HUH) surgeons, either locally or at HUH. Communication relied on personal emails and phone calls. Continuity of care was promoted by active dialogue and virtual case meetings and national care protocols and research projects.

hernia patients possibly requiring ECMO treatment are managed in HUH. Finally, we wanted to promote involvement of trainees in FPSH activities, including operations and virtual case meetings.

2.3. Patients and operations

All cases addressed by FPSH during 2021–2023 were prospectively registered and included in the present study.

2.4. Data collection

Demographics, time of diagnosis and surgery, underlying diagnosis, operative characteristics and associated short term (occurring within 30 days) postoperative complications were retrospectively collected from the medical records in each center. Complications were graded according to Clavien-Madadi classification [9].

2.5. Statistical analyses

Data are presented as frequencies or median with interquartile range. Mann–Whitney U test or Fischer exact test were used for comparisons. A P-value less than 0.05 was considered statistically significant.

2.6. Ethics

For this register-based study no ethical approval or informed consent was required according to Finnish legislation as patients were not contacted.

4. Results

4.1. Operations managed by FPSH

The number of operations managed by FPSH picked up rapidly after the first surgery performed in June 2021 (Table 1). During 2021–2023, a total of 40 operations were managed by FPSH. As detailed in Table 1, median age at surgery was 7.3 months and median waiting time from the index diagnosis to surgery was 3.5 months. Age at index diagnosis and surgery or waiting time to surgery were comparable in operations performed in local hospitals or HUH ($P > 0.05$ for all comparisons).

Overall, 30 (75%) operations were performed in local hospitals, of which 25 (83%) were elective cases (see below), while five (17%) were considered urgent, including primary repair of type C esophageal atresia (EA; n = 2), and left sided congenital diaphragmatic hernia (n = 1), resection of sacrococcygeal teratoma in a newborn (n = 1), and a case of complicated postoperative peritonitis (n = 1). The urgent operations at local hospitals were mostly performed on the next day after median delay of 1 (range, 1–3) day.

Overall, 10 operations (25%) were deemed safest to perform in HUH, including nine elective cases (see below) and one urgent primary repair of type C EA in a premature (birth weight 1000g) newborn operated on the day of transfer.

4.2. Underlying surgical diagnoses

The underlying surgical diagnoses represented a wide spectrum of neonatal surgical conditions, which were either operated primarily (n = 27, 67%) or underwent revisional surgery for complications or long-term issues (n = 13, 33%). The most common underlying diagnosis was anorectal malformation, followed by EA, Hirschsprung disease, tumors/oncology, congenital diaphragmatic hernia and sacrococcygeal teratoma (Table 1). The 10 patients, who were operated at HUH underwent primary posterior sagittal vaginourethroplasty for a high cloaca, delayed primary esophageal anastomosis of type B and type C EA, jejunal interposition for type A EA, primary repair of type C EA in a severely premature newborn with vestibular fistula (see above), ileo-anal anastomosis with J-pouch for total colonic aganglionosis, prophylactic thyroidectomy for multiple endocrine neoplasia 2B, resection of ganglioneuroblastoma and

Table 1
Operations coordinated and managed by FPSH during 2021–2023.

	All	At local hospitals	At HUH
Operations, n (%)	40	30 (75)	10 (25)
2021	2	2	0
2022	14	10 (71)	4 (29)
2023	24	18 (75)	6 (25)
Age at diagnosis, m	1.5 (0–19)	2.0 (0–25)	0.05 (0–10)
Age at surgery, m	7.3 (3.4–23)	8.6 (3.4–29)	6.6 (4.8–15)
Neonatal operations, n (%)	5 (13)	4 (13)	1 (10)
Waiting time from diagnosis, m	3.5 (1.1–5.7)	3.4 (1.1–4.4)	4.8 (2.4–6.5)
Elective case, n (%)	34 (85)	25 (83)	9 (90)
Waiting time, m	4.0 (1.4–6.5)	3.8 (1.4–5.7)	4.8 (2.5–6.6)
Urgent cases, n (%)	6 (15)	5 (17)	1 (10)
Waiting time, d	1 (1–2)	1 (1–2)	1
Underlying surgical diagnosis, n			
Anorectal malformation	10	9	1
Primary repair	6	5	1
Revisional surgery	4	4	0
Esophageal atresia	8	4	4
Primary repair	3	2	1
Delayed/reconstruction	5	2	3
Hirschsprung disease	7	6	1
Primary pull-through	6	5	1
Re-do pull-through	1	1	0
Tumor/oncology	5	3	2
Congenital diaphragmatic hernia	3	3	0
Primary repair	1	1	0
Recurrent hernia repair	2	2	0
Sacrococcygeal teratoma	3	3	0
Primary resection	2	2	0
Resection of residual tumor	1	1	0
[a]Other operations	4	2	2

Data are frequencies or median (interquartile range). HUH, Helsinki University Children's Hospital.
[a] Other operations included tapering of dilated small bowel due to intestinal atresia and short bowel syndrome, complicated postoperative peritonitis, thoracoscopic excision of esophageal duplication, and thoracoscopic removal of extralobular sequestration.

thoracoscopic removal of esophageal duplication and an extralobar sequester.

4.3. Surgical complications

Overall, 12 (30%) patients had any early (<30 days) postoperative complications and five (13%) required any reoperation (Table 2). Majority of Clavien-Madadi complication grades were IIIA or lower, while no Grade IV (multiorgan dysfunction) or V (death) were recorded. Rate and grade of complications were comparable between patients operated in local hospitals or in HUH ($P > 0.05$ for both comparison). Individual complications are detailed in Table 3. One patient with type C EA required postoperatively an unintended transfer from a local hospital to HUH intensive care unit due to prolonged intubation after successful delayed primary anastomosis.

Table 2
Short-term (<30 days) complications according to Clavien-Madadi classification in operations performed at local hospital or HUH.

	All patients	At local hospitals	At HUH
Patients, n	40	30	10
Any complication, n (%)	12 (30)	9 (30)	3 (30)
[a]Any re-operation <30 d, n (%)	5 (13)	3 (10)	2 (20)
Clavien-Madada Grade, n			
Grade I A	1	1	0
Grade I B	3	3	0
Grade II	1	0	1
Grade III A	5	4	1
Grade III B	2	1	1
Grade IV	0	0	0
Grade V	0	0	0

HUH, Helsinki University Children's Hospital.
[a] Re-operations included laparotomy-wound revision (n = 1), laparotomy for evacuation of pelvic hematoma (n = 1), posterior sagittal closure of rectum perforation (n = 1), tracheostomy (n = 1) and thoracotomy with esophagostomy (n = 1).

4.4. Other deliverables

During 2021–2023, national management and follow-up protocols for EA and Hirschsprung's disease were completed and started for anorectal malformations. Research projects involving all five Finnish centers were launched including national registry-based studies on postoperative outcomes and cancer risk of EA and choledochal malformations, and a randomized controlled trial on symptomatic treatment of uncomplicated appendicitis [10].

5. Discussion

In addition to introducing principles and our early experiences of FPSH, one of the main aims of this study was to assess surgical safety. To assess early postoperative complications, we used recently described the Clavien-Madadi classification for detection of both surgical and non-medical errors [9]. According to the Clavien-Madadi classification, most of the early postoperative complications occurring overall in 30% of patients were relatively minor and commonly described problems without significant added morbidity. Moreover, postoperative complication occurred with comparably frequence and severity grades after operations performed at local hospitals or HUH, while only one patient required an unintended postoperative transfer from a local hospital to HUH. However, any reoperations, including two laparotomies and one thoracotomy were required in five (13%) patients, two of which undoubtably carry significant long-term consequences. These complications included tracheostomy for vocal cord paralysis

Table 3
Description of short-term (<30 days) operative complications according to Clavien-Madadi classification.

Grade	N	At local hospitals	At HUH
I A	1	Unplanned postoperative transfer to HUH	–
I B	3	Bedside care of wound infection/dehiscence (n = 2) Rectal tube decompression after primary PT	–
II	1	–	Non-invasive respiratory support after thyroidectomy
III A	5	Laparotomy-wound dehiscence after re-do PT Delayed extubation after primary EA (type C) repair Chest drainage for chylothorax after primary CDH repair Rectum perforation after laparoscopic ARM repair	Tracheostomy after delayed EA (type B) repair
III B	2	Evacuation of pelvic hematoma after PT	Anastomotic leakage after delayed EA (type C) repair
IV	0	–	–
V	0	–	–

HUH, Helsinki University Children's Hospital; PT, endorectal pull-through for Hirschsprung disease; EA, esophageal atresia; CDH, congenital diaphragmatic hernia; ARM, anorectal malformation.

after delayed repair of type B EA, and cervical esophagostomy due to late anastomotic leakage after delayed repair of type C EA in a former preemie. Both operations were rightly scheduled and performed in HUH with the best intensive care resources to handle these complications and surgical preparedness to take care of further operative management with laryngotracheal expansion and esophageal reconstructive surgery. These findings suggest that the place of care was appropriately appointed by FPSH for the great majority of the patients and that postoperative complications were not associated with the place of care. We were also able to perform urgent operations without unusual or harmful delay, even though most of them were performed at local hospitals requiring short notice travelling by HUH surgeons.

After demonstrating surgical safety, it is equally important to transparently address effects on long-term outcomes in the future. This requires introduction of structural registry-based follow-up within FPSH, preferentially employing already existing high-quality platforms enabling international benchmarking, such as EPSA|ERNICA registry for rare congenital malformations [11]. Thus far, there is limited evidence available supporting centralization of wider range of neonatal surgical conditions [5,8], although it has been shown to improve outcomes of demanding conditions like biliary atresia and neuroblastoma [3,4,12]. In this respect, it will be very interesting to learn how quite recent centralization of Hirschsprung disease, anorectal malformations, congenital diaphragmatic hernia, and EA in Sweden and in the Netherlands affects outcomes of these patient groups [5,8].

Finland has a national healthcare system with five collaborative areas for healthcare and social welfare, each with one university hospital which organizes regional pediatric surgical care. However, the number of patients is unevenly distributed throughout the country due to steep regional differences in population density and birth rate, which has decreased notably during recent years. Although all Finnish neonatal surgical patients could be managed volume-wised by centralization to one well-equipped children's hospital, this could compromise provision and equal access to pediatric surgical services in the rest of the country.

While we believe that FPSH has provided many advantages over traditional centralization in Finland we have also collectively agreed that certain patient groups benefit from concentration of care. Typically, these conditions represent rare and complex conditions benefiting from increased exposure by requiring continuous multidisciplinary input from a variety of specialists in addition to surgical expertise and supportive medical technology. In line with this, according to the latest FPSH update, patients with type A or B EA, esophageal reconstructions and re-operations, airway surgery, near total or total colonic aganglionosis, complex anorectal malformations, hepatobiliary and pancreas surgery excluding gallstone disease, and congenital diaphragmatic hernia patients possibly requiring ECMO treatment are managed in HUH. Local surgeons are encouraged to travel with their patients to also participate these operations, which together with joint operations performed locally and other FPSH clinical activities markedly improves learning opportunities, consistency and equality of surgical care across different hospitals, and preparedness to provide crucial follow-up services nationally. An obvious advantage for patients and their families is that in many cases they can stay near home without a need to travel. One disadvantage of FPSH is scattering of cases among the five hospitals, which may challenge introduction of new surgical techniques and performance clinical trials as the number of certain patients remain relatively low in each center.

This study had several limitations, including retrospective clinical data collection, although patients were prospectively registered. We couldn't assess postoperative complications of those patients, who were treated without being addressed by FPSH as these patients were not recorded. In addition to addressing these issues in future studies, it will be also crucial to analyze how FPSH affected core outcomes and compare them to other countries practicing centralization of pediatric surgical care.

These preliminary findings suggest that our national collaborative initiative, FPSH, started by pediatric surgeons themselves not only provided practical and safe framework for sharing of surgical expertise but also for collective learning. While further development of FPSH activities will require structural registry-based follow-up, regular updating and firm administrative support, our goal is to combine all five university hospitals to function virtually as one national pediatric surgical unit providing standardized and equal high-quality care with improved training opportunities and being collectively accountable for national outcomes of pediatric surgery.

Financial support

Sigrid Jusélius Foundation (MPP), Finnish Pediatric Research Foundation (MPP), Helsinki University Hospital Fund (MPP), Päivikki & Sakari Sohlberg Foundation (AR). The funding sources were not involved in conduct of the research, study design, collection, analysis, interpretation of the data, nor in preparation of the article or decision to submit the article for publication.

Conflict of interest

Authors have no competing interests to declare.

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