Development of Pediatric Minimal Invasive Surgery in Mainland China

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Abstract

With the help of international collaborative training programs, pediatric laparoscopy developed rapidly in the past 20 years in mainland China. High volume laparoscopic workload enables Chinese pediatric surgeons to gain experience, improve techniques within a short span of time, and innovate novel laparoscopic techniques and procedures. Our experiences suggested that laparoscopy in children is safe. Its outcomes are comparable or superior to that of open surgery. Both patients and pediatric surgeons have benefited from this revolutionary technique. In this article, we share our experience of rapid development of pediatric laparoscopy in mainland China.

Keywords: minimal invasive surgery; laparoscopy; training; innovation; children

I. Development of Pediatric Surgery in Mainland China

China is a large populous developing country with a population of 1.3 billion. Historically, China was poor economically after a period of extended isolation from the West. Since 1978, the Chinese government adopted an Open Door Policy; thereafter, China rapidly evolved into the world's second largest economy.

Pediatric surgery in mainland China is relatively young. It developed in 1956 and was modelled after the Soviet Union medical system. International exchange after the adoption of the Open Door Policy helped to modernize the specialty in China. The father of pediatric surgery in mainland China, Jin-zhe Zhang, won the Denis Browne Prize in 2000. Chinese pediatric surgeons were eager to learn the advanced knowledge and experiences from the West. They went to the United States (US), United Kingdom (UK), European countries, Japan and Hong Kong for training. In 1995, initiated by Tomas Steplaton, the former president of World Federation of Pediatrics, and sponsored by British Association of Pediatric Surgeons (BAPS), Dr. Long Li attended the 42nd BAPS annual meeting in Sheffield, and visited six pediatric surgical centers in the UK, including Sheffield Children's Hospital, Royal Hospital for Sick Children in Glasgow, Royal Hospital for Sick Children in Edinburgh, Alder Hey Children's Hospital, Great Ormond Street Hospital, and Southampton General Hospital. The UK learning experience signified the beginning of East-West exchange and it has profoundly influenced Long LI's career. In 1997, immediately after Hong Kong returned to China, PKH Tam, Chair of Pediatric Surgery of the University of Hong Kong, and 2017 Denis Browne Prize winner, established the "Train-the-Trainer" program for Mainland Chinese pediatric surgeons. Dr. Long Li was the first trainee in this program. To date, over 50 pediatric surgeons

from mainland China have taken part in this program. In 2000, as a visiting fellow, Long Li had training in pediatric laparoscopic surgery in Department of Pediatric Surgery, Juntendo University School of Medicine, under the guidance of T Miyano and A Yamataka. Meanwhile, he also undertook training on pediatric liver transplantation, under the supervision of H Kawarasaki, Department of Pediatric Surgery, Tokyo University, Japan. Till now, 350 Chinese pediatric surgeons have undertaken laparoscopic trainings overseas. The majority of them became leaders in regional pediatric laparoscopic centers, and played important roles in the development of pediatric laparoscopy in mainland China.

II. Development of Pediatric Minimally Invasive Surgery in Mainland China

Pediatric minimally invasive surgery in mainland China started in 1981. Stephen Gans, the editor-in-chief of Journal of Pediatric Surgery, firstly introduced laparoscopic technique to Chinese pediatric surgeons, and donated the first laparoscope to Jin-Zhe Zhang in Beijing Children's Hospital (Fig. 1). Using this laparoscope, Jin-Zhe Zhang developed the diagnostic procedures for infantile jaundice and gonadal dysgenesis. The development of pediatric minimally invasive surgery in mainland China can be divided of into four growth phases:

Phase I (1981-1996) - Sowing the seed of laparoscopy in mainland China: In this period, two diagnostic procedures for infantile jaundice and gonadal dysgenesis were developed.

Phase II (1997- 2000) – Developing pediatric laparoscopic techniques: With the development of adult laparoscopic surgery, particularly with the advent of endo-clips and dissection skills, a few adult and pediatric surgeons who learnt laparoscopy from adult surgeons, started incisional or excisional procedures, i.e. appendectomy, herniotomy,

pyloromyotomy, varicocelectomy, nephrectomy for non-functioning kidney, and cholecystectomy.

Phase III (2001-2008) – Rapid expansion of reconstructive pediatric laparoscopy: 79 laparoscopic procedures were established with the developments of intra-corporeal knotting and hand suturing techniques. Since 1996, quite a few world-famous experts introduced the modern pediatric laparoscopy to mainland China, including KE Georgeson, S Rothenberg, GW Holcomb III from the US, PKH Tam, CK Yeung, W Cheng, KK Wong from Hong Kong, T Miyano, A Yamataka from Japan, and NK Alizai from the UK. They made a great contribution to accelerate the development of pediatric laparoscopy in mainland China. During this phase, a large number of major laparoscopic reconstructive procedures were developed, including Nissen fundoplication, diaphragmatic hernia repair, pyeloplasty, hepaticojejunostomy for choledochal cyst, pull-through for Hirschsprung's disease, and anorectoplasty for anorectal malformations with vesical or prostatic fistulae (Fig. 2). In December 2001, the first pediatric laparoscopic workshop in mainland China was organized by Long LI, the Chief of Pediatric Surgery, the First Affiliated Hospital of Peking University (Fig. 3). Since 2007, PKH Tam, KK Wong and prominent experts from mainland China collaborated in running the twice-yearly the Hong Kong - mainland China Laparoscopic Workshop [1] (Fig. 4). Many participants developed laparoscopic techniques in regional centers and became local pediatric laparoscopic leaders thereafter.

Phase IV (2009-now) – Gradual maturation period of pediatric laparoscopy: Laparoscopy has gained wide acceptance by both pediatric surgeons and patients' parents. It has been become the preferred treatment option for many surgical conditions.

Since 2011, a series of innovative procedures have been developed, including complicated surgical procedures, e.g. single-incision laparoscopic hepaticojejunostomy for choledochal cysts [2-8] and correctable biliary atresia [9] , one-stage single-incision laparoscopic-assisted anorectoplasty for newborns with anorectal malformations with rectourethral fistulae [10]. The advantages of single-incision laparoscopic surgery include: 1) a single umbilical incision for gallbladder and choledochal cyst removal, Roux loop formation [7] or bowel decompression with a virtually scarless postoperative appearance [10]; 2) the use of conventional laparoscopic instruments; 3) outcomes comparable to those of conventional laparoscopic procedures including operative time, postoperative recovery and complication rate after the learning curve [7]; and 4) the advantage of being more suitable for younger children because of their more stretchable abdominal wall (our unpublished data) and shallower pelvic cavity [10]. Single-incision laparoscopic procedures in these reconstructive pediatric surgical procedures in some mainland Chinese centers have attracted world-wide interest.

In 2009, The Chinese Pediatric Endo-surgery Committee was accredited by the Ministry of Health of China. In 2011, The Chinese Pediatric Endo-surgery Group (CPEG) was established. Long Li was elected to be the founding chairman of above two organizations. These organizations provide national platforms for Chinese pediatric laparoscopic surgeons to exchange and update their knowledge and skills, and set up a national network for training and academic activities.

Based on the CPEG database, till now, over 500,000 pediatric laparoscopic procedures have been carried out nationwide. Nearly 4000 laparoscopic hepaticojejunostomies for choledochal

cysts have been conducted in 45 centers by 61 surgeons. Nearly 2000 laparoscopic-assisted anorectoplasties for anoretal malformations with rectourethral fistulae have been carried in 23 centers by 23 surgeons. Nearly 6000 laparoscopic-assisted pull-through procedures for Hirschsprung's disease have been performed in 47 centers by 103 surgeons. Over 5000 pyeloplasties have been conducted in 24 centers by 26 surgeons. More recently, laparoscopic Warren procedure and hepatic lobectomy have been developed in a few centers.

Between 2013 and 2017, as principle investigator of a national research project supported by the Ministry of Health of China, Long LI formed a consortium with 7 pediatric laparoscopic centers in mainland China to establish a national database, training programs, evaluation systems and guidelines, and published a textbook of pediatric laparoscopy. Between 2017 and 2018, the guidelines of laparoscopic treatment for children with choledochal cysts, anorectal malformations, Hirschsprung's disease, congenital diaphragmatic hernia, vesicoureteral reflux, and hydronephrosis were published in the Chinese Journal of Pediatric Surgery [11-14]. The first textbook of pediatric laparoscopic surgery accredited by the Ministry of Health of China has been published in 2017 as well.

During this phase, championed by Long LI, the Beijing center strives to improve the international exchange. More and more pediatric laparoscopic surgeons from mainland China participate in the annual meeting of International Pediatric Endoscopy Group (IPEG), presenting scientific papers and delivering lectures. In mainland China, the annual publications on pediatric laparoscopic surgery in Chinese and English exceeded the publications on open surgery in 2010 and 2012 respectively. With help from PKH Tam and CK Yeung, the Beijing center cooperated with IPEG and organized the first global interactive

internet course on pediatric minimal invasive surgery in 2011, and the first IPEG Annual Congress in mainland China in 2013. In a pre-Congress session of live surgery demonstration lasting less than 5 hours, laparoscopic-assisted anorectoplasty for imperforated anus, pneumovesical ureteral reimplantation, thoracoscopic repair of esophageal atresia and pulmonary lobectomy, and single-incision laparoscopic hepaticojejunostomy for choledochal cyst were successfully completed by KE Georgeson, CK Yeung, S Rothenberg, and Long LI respectively. As appreciation of international assistance, the Beijing center reciprocated by providing training opportunities for visiting fellows from the US, UK, Hong Kong, Chinese Taiwan, Mexico, Pakistan etc. Meanwhile, Long LI was invited to deliver lectures and perform live surgeries in laparoscopic workshops in India, Pakistan, and Vietnam as international mentors.

III. Hurdles in Pediatric Minimal Invasive Surgery and Resolutions

Compared with the adult laparoscopy, pediatric laparoscopy is more challenging because of restricted working space and advanced technical demands. A good training is helpful to overcome the difficulties.

1. Laparoscopic workshops

The Hong Kong - mainland China Laparoscopic Workshop started in Beijing, and rotated through 25 regional pediatric surgical centers afterwards, covering developed and underdeveloped regions, like Xin Jiang in northwest China.

Live laparoscopic surgeries for trainees at different levels, guided by experienced prominent

experts, are the most important part of the workshop. The procedures include appendectomy, herniotomy, orchidopexy, splenectomy, pull-through for Hirschsprung's disease, hepaticojejunostomy for choledochal cyst, pyeloplasty for pelvi-ureteral junction obstruction, esophageal atresia repair and pulmonary lobectomy. Before the 2013 IPEG live surgery in Beijing, thoracoscopic repair of esophageal atresia and pulmonary lobectomy were developed in only one center in mainland China. Shortly after the live show, these two procedures were started in additional six and five centers respectively.

In the past 11 years, 2584 participants (60% of pediatric surgeons in mainland China) accomplished the training in the series of workshops. Those who evolved to national or regional pediatric laparoscopic leaders collaborated to develop training programs in regional hospitals, and taught local surgeons with a hands-on approach in regional hospitals. With this, the seeds of pediatric laparoscopy were sown all over the country rapidly. Six national accredited pediatric laparoscopic training centers have been established in Beijing (Capital Institute of Pediatrics, Long LI), He Bei (The 2nd Affiliated Hospital of He Bei Medical University, Suo-Lin LI), Hu Bei (Wu Han Union Hospital, Shao-Tao TANG), Shang Hai (Shanghai Children’s Medical Center, Yu-Li BI), Xin Jiang (People’s Hospital, Shui-Xue LI) etc. The young generation has laparoscopic training in these centers nowadays. Interestingly, our review found that the learning curves have been significantly shortened in the new centers. Prior training in the developed centers is crucial for this steep learning (Fig. 5) [15].

2. Training Program and Assessments of Pediatric Laparoscopy in mainland China

As shown in Table 1, the 100-hours training program was constructed as follows:

Level 1: Lectures are delivered by prominent experts (10 hours), introducing the functions, maneuvers, and maintenance of laparoscopic equipment and instruments, fundamental principle of laparoscopy, basic laparoscopic surgery steps, principle of complication managements and preventions, and indications for conversion to open surgery. Assessment consists of a written examination and a score above 80/100 marks qualifies the candidate for admission to level 2 training;

Level 2: Box training (60 hours) includes knot tying (40 hours) and suturing (10 hours) on animal organs, such as pig's intestine, kidney with ureters, and esophagus; and telescope holding techniques (10 hours). Assessment requires accomplishing one square knot within 60 seconds, finishing one stitch within 60 seconds, and good cooperation between the telescope holder and the surgeon;

Level 3: Animal model practice (10 hours) includes trocar placements, dissection, hemostasis, excisional surgeries, e.g. bowel resection, cholecystectomy, splenectomy etc. Assessment requires the trainee to independently finish the above procedures;

Level 4: Observation of laparoscopic surgeries (10 hours) include numbers of Grade 1 surgery > 3, Grade 2 surgery > 2, Grade 3 surgery: 1-2, Grade 4 surgery: 1-2. Assessment requires completion of the above observations;

Level 5: Participation of live laparoscopic surgeries (10 hours): as telescope holder: 1-2 surgeries, as the 2nd assistant: 1 surgery, as the 1st assistant: 1 surgery, as surgeon: 1 surgery. Assessment requires completion of the above live laparoscopic surgeries.

1) Elementary laparoscopic training

Because inguinal hernia is a common condition in children, intra-corporeal suturing repair of inguinal hernia is an optimal procedure for trainees when they start laparoscopic practice. It is helpful to improve laparoscopic skill within a short period.

2) Advanced laparoscopic training

The module of advanced laparoscopic procedures training is divided into several segments at different levels. “Divide and conquer” strategy is important in simplifying a complex task.

For example, the laparoscopic definitive surgery for choledochal cyst are divided into 6 segments at different levels: Level 1: intra-operative cholangiogram plus liver biopsy; Level 2: cholecystectomy; Level 3: Roux loop and retro-colonic tunnel formation; Level 4: cyst excision: 4a: anterior wall dissection, 4b: distal stump management, 4c: posterior wall dissection, 4d: proximal common hepatic duct management; Level 5: hepaticojejunostomy: 5a: anterior wall anastomosis, 5b: posterior wall anastomosis; Level 6: 6a: ductoplasty for hepatic duct stricture, 6b: management of aberrant hepatic duct, 6c: re-positioning of aberrant right hepatic artery behind proximal common hepatic duct. After proficiently accomplishing lower level training, trainees can move to training at more advanced levels. Once trainees proficiently accomplished level 1-6 training segments in uncomplicated cases, they can start laparoscopic practice in complicated cases, i.e. surgery for giant choledochal cyst, neonatal choledochal cyst, redo surgery, and perforated choledochal cysts step by step.

3. Training of “Simple and Effective Techniques”:

In mainland China, the shortage of advanced equipments affects pediatric medical practice.

We developed some simple and effective techniques, and included these techniques in laparoscopic training, such as the application of trans-abdominal retraction sutures to facilitate dissection and anastomosis [2, 4-6], removal of protein plugs in common channel by normal saline irrigation through urethral catheter [16], 180 degree telescope rotation for recto-urethral fistulae repair in direct vision [10, 17] etc. We also simplified some procedures to avoid excessive dissection and minimize tissue damage [18].

4. Training on the knowledge of disease, preoperative evaluation and perioperative management

Successful laparoscopic practice also relies on the knowledge of disease, preoperative evaluation and perioperative managements. Clinical research on the etiology of disease, the associated anomalies/ anatomical variations which require surgical correction or cautions, operative video editing, and scientific article writing are helpful for both junior and senior trainees to understand the difficulties and resolution, complications and preventions, and to master the key-points of techniques. Training for preoperative evaluation and perioperative multidisciplinary treatment is fundamental to ensure successful laparoscopic surgeries.

Constant self-learning from experiences of different surgical procedures as well as learning from adult laparoscopic surgery is necessary for self-improvements.

5. Non-Technical Skills Training:

Training of three non-technical skills, i.e. cognitive, social and positive attitudes [19], are included in our training programs. It is important to improve the surgeon's comprehensive

abilities.

1) Cognitive skills include clinical awareness, decision-making and planning. Higher technical intricacies of laparoscopic procedures demand detailed planning and careful decision-making.

2) Social skills encompass communication, teamwork and leadership abilities. Effective communication is crucial for the safe performance of any surgical procedure.

3) Personal attitudes include the ability to cope with the stress and fatigue commonly experienced by surgeons.

Amongst the various non-technical skills, decision-making is shown to improve with experience [20].

In summary, the rapid development of pediatric laparoscopy in mainland China is attributed to: 1) international collaborative training programs with live surgeries which provide face-to-face interaction with pioneers; 2) national training network which popularizes the new knowledge and techniques; 3) the establishment of high volume centers which enables quick accumulation of experiences within a short period of time. These centers facilitate clinical research and development of innovative laparoscopic procedures; 4) training of the regional leaders in high volume centers; 5) simple and efficacious technical tips to overcomer the insufficiency of advanced equipments, and minimize the morbidities.

Our experience has confirmed that laparoscopy in children is safe, and can achieve comparable or superior surgical outcomes as open surgery. Both patients and pediatric surgeons have benefited from this revolutionary technique.

In the future, the Chinese pediatric laparoscopic surgeons will strive to work closely with the international laparoscopic community and academic organizations to set up global exchange and training network, expand the minimally invasive approach to more surgical interventions, and transform the contraindications into indications for laparoscopic surgey.

References

[1] Tam PKH, Wong KK, Li L, Zhang JZ. Internationalization: the Hong Kong-China experience as a model for collaborative education in Asia. Pediatr Surg Int 2013;29(10):1053-9.

[2] Diao M, Li L, Dong N, Li Q, Cheng W. Single-Incision Laparoscopic Roux-en-Y Hepaticojejunostomy Using Conventional Instruments for Children with Choledochal Cysts. Surg Endosc 2012;26(6):1784-90.

[3] Diao M, Li L, Cheng W. Single-incision laparoscopic hepaticojejunostomy using conventional instruments for neonates with extrahepatic biliary cystic lesions. Surg Innov 2013;20(3):214-8.

[4] Diao M, Li L, Li Q, Ye M, Cheng W. Challenges and strategies for single-incision laparoscopic Roux-en-Y hepaticojejunostomy in managing giant choledochal cysts. Int J Surg 2014;12(5):412-7.

[5] Diao M, Li L, Cheng W. Laparoscopic redo hepaticojejunostomy for children with choledochal cysts. Surg Endosc 2016;30 (12)(12):5513-9.

[6] Diao M, Li L, Cheng W. Single-incision laparoscopic hepaticojejunostomy for children with perforated choledochal cysts. Surg Endosc 2018;32(7):3402-9.

[7] Diao M, Li L, Li Q, Ye M, Cheng W. Single-incision versus conventional laparoscopic cyst excision and Roux-Y hepaticojejunostomy for children with choledochal cysts: a case-control study. World J Surg 2013;37(7):1707-13.

[8] Diao M, Li L, Cheng W. Role of laparoscopy in treatment of choledochal cysts in children. Pediatr Surg Int 2013;29(4):317-26.

[9] Diao M, Li L, Cheng W. Initial experience of single-incision laparoscopic hepaticojejunostomy using conventional instruments for correctable biliary atresia. J Laparoendosc Adv Surg Tech A. 2012;22(6):615-20.

[10]Diao M, Li L, Ye M, Guan KP, Wei YD, Cheng W. Congenital anomaly rectified at birth: one-stage single-incision laparoscopic-assisted anorectoplasty for newborns with anorectal malformations and recto-urethral fistula. Surg Endosc 2016;30(11):5156-64.

[11]Diao M, Chen Z, Li L, Chinese Pediatric Endo-surgery Group, Chinese Association of Pediatric Surgeons. The Guidance of Laparoscopic Cyst Excision and Hepaticojejunostomy for Children with Choledochal Cysts. Chin J Pediatr Surg 2017;38(7):5-11.

[12]Diao M, Chen Z, Li L, Chinese Pediatric Endo-surgery Group, Chinese Association of Pediatric Surgeons. The Guidance of Laparoscopic-assisted Anorectoplasty for Anorectal Malformations Chin J Pediatr Surg 2017;38(9):645-53.

[13]Tang ST, Chinese Pediatric Endo-surgery Group, Chinese Association of Pediatric Surgeons. The Guidance of Laparoscopic-assisted Pull-through for Hirschsprung's disease. Chin J Pediatr Surg 2017;38(4):247-54.

[14]Li SL, Chinese Pediatric Endo-surgery Group, Chinese Association of Pediatric Surgeons. The Guidance of Thoracoscopic Repair of Congenital Diaphragmatic Hernia Chin J Pediatr Surg 2018;39(1):1-8.

[15]Qiao G, Li L, Li S, Tang S, Wang B, Xi H, et al. Laparoscopic cyst excision and Roux-Y hepaticojejunostomy for children with choledochal cysts in China: a multicenter study. Surg Endosc 2015;29(1):140-4.

[16]Diao M, Li L, Zhang JS, Cheng W. Laparoscopic-assisted clearance of protein plugs in

the common channel in children with choledochal cysts. J Pediatr Surg 2010;45(10):2099-102.

[17] Diao M, Li L, Ye M, Cheng W. Single-incision laparoscopic-assisted anorectoplasty using conventional instruments for children with anorectal malformations and rectourethral or rectovesical fistula. J Pediatr Surg 2014;49(11):1689-94.

[18] Diao M, Li L, Cheng W. Is it necessary to ligate distal common bile duct stumps after excising choledochal cysts? Pediatr Surg Int 2011;27(8):829-32.

[19] Flin RH, O'Connor P, Crichton M. Safety at the sharp end: a guide to non-technical skills. Aldershot, England and Burlington, VT: Ashgate Publishing; 2008.

[20] Flin R, Youngson G, Yule S. How do surgeons make intraoperative decisions? . Quality Safety Health Care 2007;16:235-9.

Figure 1 Stephen Gans (left) firstly introduced laparoscopic technique to Chinese pediatric surgeons, and donated the first laparoscope to Jin-Zhe Zhang (right) in Beijing Children's Hospital

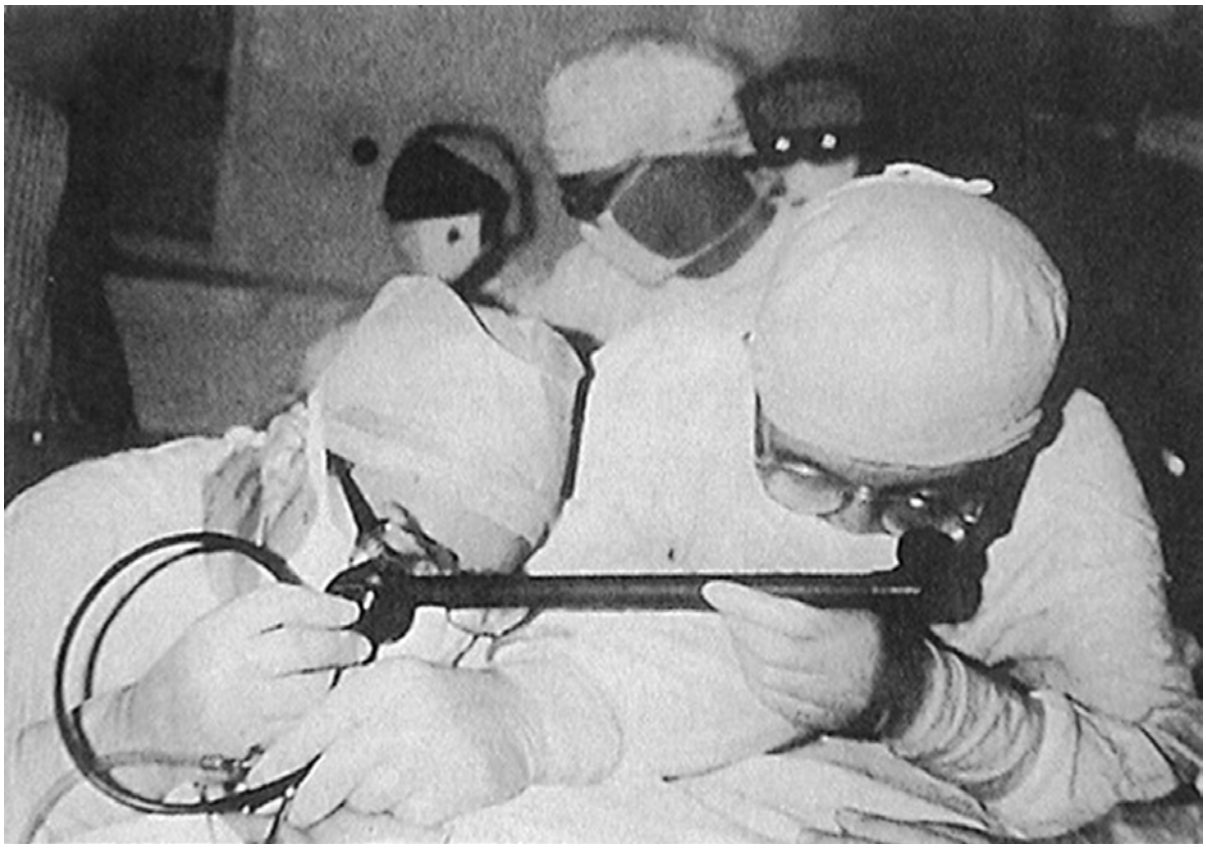
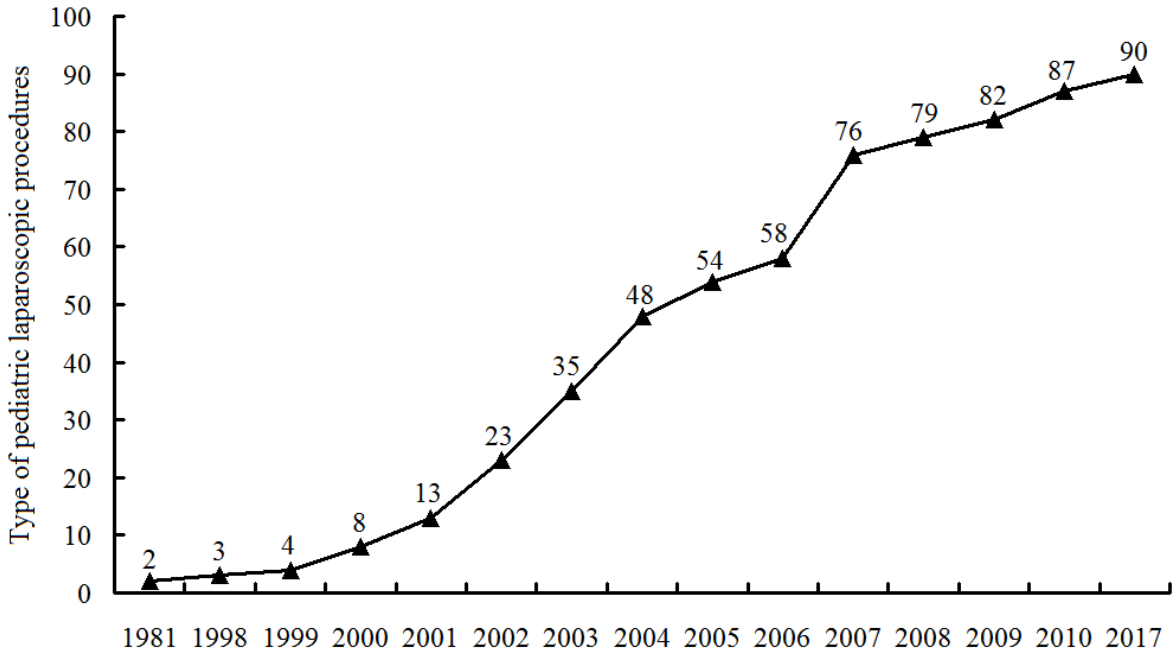


Figure 2 Development of pediatric laparoscopic and thoracoscopic procedures in mainland China: Two leaps in pediatric laparoscopy development can be detected after the first national laparoscopic workshop in 2001, and the first Hong Kong-Mainland China laparoscopic workshops in 2007 respectively. Laparoscopic techniques are broadly applied in 90 various pediatric surgical procedures nowadays.



1 Appendectomy
2 Herniotomy (Tuohy needle hernia device, Inner two-hooked cannula, Single inner ring suture, Hydrodissection of posterior peritoneum)
3 pyloromyotomy
4 Pyloroplasty
5 Endoscopic pylorotomy
6 Ladd’s procedure
7 Duodenoduodenostomy
8 Pull-through for Hirschsprung's disease
9 Liver biopsy
10 Cholecystectomy
11 Cholangiogram
12 Cholecystostomy
13 Hepaticojejunostomy for Choledochal cyst
14 Cholecystolithiasis clearance
15 Ductoplasty for hepatic duct stricture
16 Repositioning of aberrant right hepatic artery behind common bile duct
17 Removal of intrahepatic bile duct stones
18 Hepaticoduodenostomy for choledochal cyst
19 Cysto-cholecystostomy for hepatic cysts and cystic dilatation of main hepatic ducts

20 Cholecystocolostomy for progressive familiar intrahepatic cholestasis
21 Kasai procedure for Type III BA
22 Hepaticojejunostomy for Type II and I BA
23 Intestinal biopsy
24 Biopsy of retroperitoneal tumor
25 Anorectoplasty
25 One-stage anoplasty for newborns with anorectal malformation and rectourethral fistulae
27 Megarectum resection
28 Sigmovaginoplasty
29 Nissan fundoplication
30 Resection of pancreatic tumor
31 Partial excision of pancreas (90%)
32 Pancreatoduodenectomy (Wipple’s procedure)
33 Pancreatojejunostomy
34 Resection of liver tumor (Marginal, size<=5cm)
35 Left lateral hepatectomy
36 Left hepatectomy
37 Right hepatectomy
38 Denudation of hepatic echinococcosis
39 Resection and anastomosis of intestinal duplication
40 Excision of mesenteric cyst
41 Excision of omentum cyst
42 Enterodialysis
43 Meckel’s diverticulum excision
44 Splenectomy
45 Partial splenectomy
46 Sugiura devascularization for portal hypertension
47 Splenic vascular ligation
48 Fenestration of splenic cysts
49 Warren shunt for portal hypertension
50 Repair of lymphatic fistula for chylous ascites
51 Oophorocystectomy
52 Excision of ovarian teratoma
53 Denudation of avarian tumor
54 Mesenteric lymph node biopsy
55 Muscle release for torticorlis
56 Thyroidectomy
57 Gonadal biopsy
58 Ligation of varicocele
59 Pyeloplasty
60 Pneumovesical ureteral reimplantation
61 Pneumovesical diverticulotectomy
62 Extravesical uretheral reimplantation
63 Orchidopexy
64 Fowler-Stephen procedure
65 Excision of prostatic utricle
66 Nephrectomy
67 Heminephrectomy
68 Ureterolithotomy
69 Cystectomy
70 Fenestration of renal cysts

71 Excision of adrenaloma
72 Ileocystoplasty
73 Decortication of lung
74 Nuss procedure
75 Extrapleural Nuss procedure
76 Repair of hiatus hernia
77 Repair of diaphragmatic hernia
78 Plication of Diaphragmatic eventration
79 Esophagus atresia repair
80 Esophagectomy
81 Esophageal cyst resection
82 Tracheal cyst excision
83 Lung biopsy
84 Resection of pulmonary metastases
85 Mediastinal Lymph node biopsy
86 Excision of mediastinal tumor
87 Fenestration of pericardium
88 Tumor biopsy
89 Pulmonary lobectomy
90 Excision of thymoma

Figure 3 The first pediatric laparoscopic workshop in mainland China was organized by Long LI, Chair of Pediatric Surgery, the First Affiliated Hospital of Peking University in December 2001. Many participants became national or local leaders of pediatric laparoscopy afterwards. The 2nd row, from left, JZ Zhang (the 7th), Long LI (the 6th), SL LI (the 11th, one of national leaders), Y Gao (the 12th, one of national leaders), WY Liu (the 13th, leader in Si Chuan); 3rd row, from left: B Xiang (the 15th, leader in Si Chuan), YL BI (the 16th, leader in Shang Hai), P LI (the 24th, leader in Shan Xi).

Figure 4 In 2007, PKH Tam and KK Wong collaborated with Long LI to organize the first Hong Kong - mainland China Laparoscopic Workshop in Capital Institute of Pediatrics, Beijing. First Row, from left, PKH Tam (the 5th), KK Wong (the 8th), JZ Zhang (the 6th), and Long LI (the 2nd).

Figure 5 The multi-center study on laparoscopic hepaticojejunostomy for choledochal cysts showed that the learning curves have been significantly shortened in the new centers. Prior training in the developed centers is crucial for this steep learning.

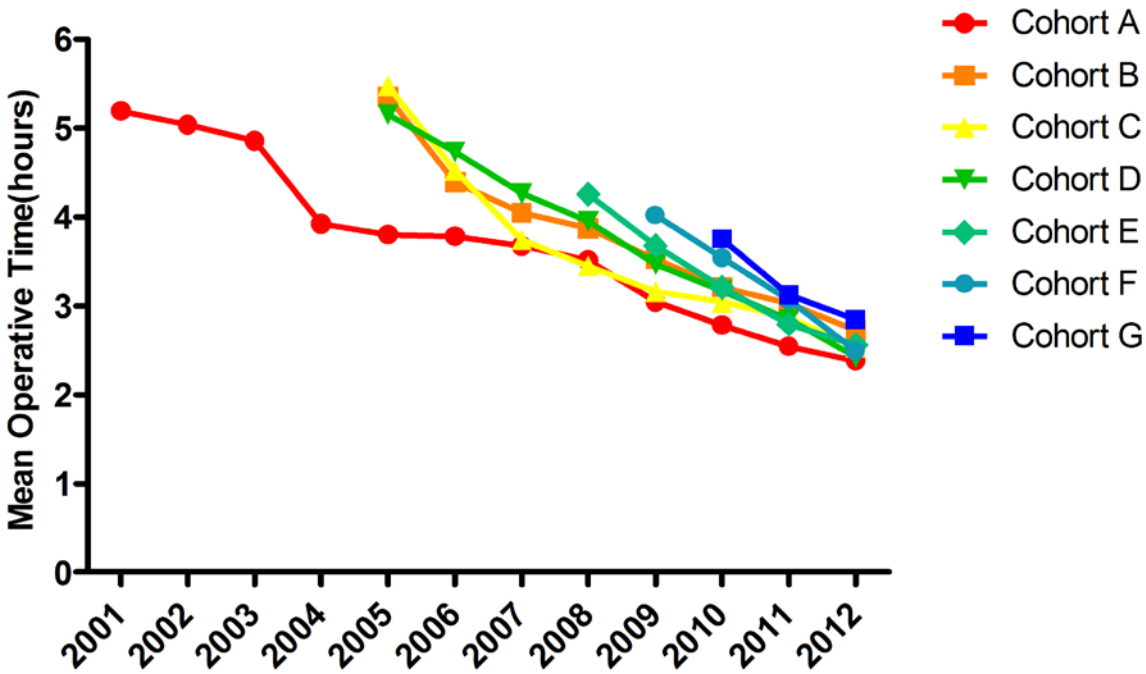


Table 1 Training program and assessments of pediatric laparoscopy in mainland China

	Training projects	Contents	Assessments
Pediatric laparoscopic training program (100 hours)	Lectures (10 hours)	Functions, maneuvers, and maintenance of laparoscopic equipments and instruments	Written examination: score >= 80/100 marks
		Fundamental principle of laparoscopy	
		Basic laparoscopic surgery steps	
		Principle of complication managements and preventions	
		Indication of conversion to open surgery	
	Box training (60 hours)	Knot tying (40 hours)	1 square knot < 60 seconds
		Suturing on animal organs (10 hours)	1 stitch < 60 seconds
		Telescope holding techniques (10 hours)	Good cooperation between telescope holder and surgeon
	Animal model (10 hours)	Trocar placements	Independently finishes deconstructive procedures on animal models
		Dissection	
		Hemostasis	
		Deconstructive surgeries: bowel resection, cholecystectomy, splenectomy etc.	

Observation of laparoscopic surgeries (10 hours):	Numbers of Grade 1 surgery: > 3 Number of Grade 2 surgery: > 2 Number of Grade 3 surgery: 1-2 Number of Grade 43 surgery: 1-2	Finishing observations
Participation of live laparoscopic surgeries (10 hours)	To be telescope holder: 1-2 surgeries To be the 2nd assistant: 1 surgery To be the 1st assistant: 1 surgery To be surgeon: 1 surgery	Finishing live laparoscopic surgeries independently