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Two decades of minimally invasive pediatric surgery—taking stock

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Abstract

Background: The past 2 decades have seen a rapid integration of minimally invasive surgery (MIS) to pediatric surgical practice. This study endeavored to delineate the current status of MIS in pediatric surgery.

Methods: Three hundred six pediatric surgeons were invited to participate in an anonymous Web-based survey. Apart from demographic details and opinion regarding robotic surgery, surgeons were asked to choose between "perform MIS," "do not perform MIS but recommend it," and "MIS not indicated" for common pediatric surgical conditions.

Results: Responses were received from 117 pediatric surgeons (38.2%). Sixty-one percent of respondents did more than 10% of their work using MIS, and 85% had more than 5 years experience in MIS. Cholecystectomy, nonpalpable testis, and exploration for abdominal pain scored highest among the positive recommendations for MIS, whereas liver tumors, biliary atresia, Wilms' tumor, and inguinal hernia scored highest among the negative recommendations for MIS. Fifty-one percent of the respondents had more than 20 years experience as a pediatric surgeon and were categorized as "senior" surgeons. Compared with the young surgeons, the senior surgeons were more likely to recommend MIS as a contraindication for simple and complicated appendicitis, reduction of intussusception, gastrostomy, fundoplication, pyloromyotomy, adhesiolysis, splenectomy, adrenalectomy, nephrectomy for dysplastic kidneys, heminephrectomy, pyeloplasty, anorectal malformations, pyeloplasty, achalasia cardia, hiatal hernia repair, lung resection, and diaphragmatic hernia repair. More than half the respondents believed that robotic surgery has a role for children in the future.

Conclusions: A widespread integration of MIS into the pediatric surgical practice is evident from this study. Current practice and recommendations of the surveyed surgeons have been outlined. Significant differences between the young and senior surgeons reflect the evolving nature of the recommendations.

Although clinical applications of minimally invasive techniques were described in the early half of the previous century, widespread use for surgery was limited until the late 1980s [1-4]. There has been a rapid integration of minimally invasive surgery (MIS) into clinical practice for the last 2 decades [5-8]. A consolidated opinion of a representative sample of pediatric surgeons delineating the current indications and contraindications of minimally invasive surgery in conditions relevant to pediatric surgical practice is absent in literature. This study was undertaken to

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elaborate the current status of minimally invasive pediatric surgery as stated by the wider, current community of pediatric surgeons.

1. Methods

1.1. Survey design

An anonymous Web-based survey was sent out to pediatric surgeons whose e-mail contact details were available with the Pacific Association of Pediatric Surgeons and the Australasian Association of Pediatric Surgeons database. The survey was designed in accordance with the standard recommendations available for Web-based surveys, based on the guidelines for reporting clinical trials [9-11]. The questionnaire was framed based on the standard recommendations to increase the response rate [12]. It was tested by 4 pediatric surgeons before being given its final design. The study was approved by the institutional review board of our hospital.

1.2. Survey content

The introductory letter for the survey briefly explained the aim of the study. An academic incentive of contributing to a body of opinion in an area poorly outlined in the literature was provided. The time taken for the survey (6-8 minutes), data protection, anonymity, and notice of subsequent reminders were provided in the covering letter. An optional space was provided at the beginning of the questionnaire to mention the institute where the surgeon worked. The first section collected demographic data. This included the number of years as a pediatric surgeon, the number of years with MIS experience, the total operative workload for number of operations per week and the proportion of surgeries being done minimally invasively. The next section was on determining the current status of MIS. For 37 common conditions encountered in pediatric surgery, the respondents were asked to choose from 1 of the 3 options, "I actually perform MIS," "I do not perform MIS but recommend it" or "I think MIS is not indicated." At the end of this section, a space was provided for those who perform MIS in conditions not listed. The final section was labeled "future of MIS" and consisted of 2 questions dealing with robotic surgery, "Do you have any personal experience in performing robotic surgery?" and "Do you think there is a role for robotic surgery in children?"

1.3. Survey administration

The questionnaire was incorporated by the webmaster of our hospital into a single webpage of the hospital Web site. The link to the webpage was provided in the covering letter. The entire questionnaire could be accessed by scrolling down to the bottom of the page, and completion of one section was therefore not mandatory to move to the next. Clicking on the mouse button was sufficient for filling in the responses. Option was available to correct the responses with autocorrection when an alternate response was selected. Clicking on the "submit questionnaire" button was necessary to bring the response in a formatted fashion to the mail inbox of the first author. Two reminders were sent after the initial mailing, and the survey was closed 45 days after the initial mailing. Duplicate entries were prevented by collecting Internet protocol (IP) addresses of the respondents. As different computers from a network in one hospital can give the same IP addresses, whenever the IP addresses were similar, the demographic data was compared, and if found matching, was considered to be a duplicate entry. In such a scenario, the second entry was deleted.

1.4. Survey analysis

If the e-mail request did not bounce back and was received by a valid e-mail address, it was considered a valid request. The response rate was ratio between the number of respondents to the number of valid requests made. The completeness rate was the number of complete responses to all the responses. The incomplete responses were not excluded, and the available information was analyzed. The responses were charted on an Excel spreadsheet (Microsoft Redmond, WA), and statistical analysis was done using SPSS 15.0 for Windows (SPSS, Chicago, Ill). Comparison between the responses from the young and the senior pediatric surgeons was done using the Pearson χ^2 tests and where appropriate the Fisher's Exact test. A P value of less than .05 was considered significant.

2. Results

2.1. Demographic data

The survey was mailed out to 390 pediatric surgeons whose e-mail addresses were available. Of these, 84 mails bounced back, giving a total of 306 valid requests. Of the 121 responses received, 4 entries were duplicate responses and were deleted. The remaining 117 responses gave a response rate of 38.2%, which compares well with other Web-based medical surveys [11]. The completeness rate was 72%. Of the 33 incomplete responses, 1 respondent mentioned that since he had retired, no questions were being answered. That response was deleted, leaving a total of 116 responses for analysis. All respondents completed the first demographic question enquiring about the number of years of practice. Hence, no further responses were deleted, and the available information was analyzed.

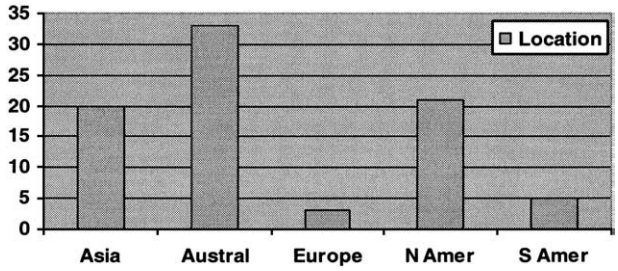

Fig. 1 Number of respondents in each geographical location.

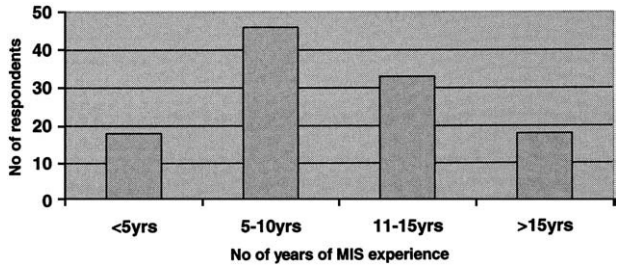

Fig. 3 Minimally invasive surgery experience.

The optional location of the workplace was identified by 82 respondents (71%). Their distribution is shown in Fig. 1. By nature of their affiliation to the organizations from where their e-mail addresses were obtained, most respondents were likely to be working in hospitals where facilities for MIS would have been available for a considerable time.

The distribution of experience as a pediatric surgeon is shown in Fig. 2. The largest group was the 21 to 30-year group (29%), and the smallest group was the less than 5 years (13%). The less than 10-year group constituted 27% of the respondents. Forty-nine percent of respondents had less than 20 years experience, and this group constitutes the group who grew up in the laparoscopic era and therefore would have had the benefit of either being trained in MIS during their residency or being exposed to MIS early in their surgical career. The categorization as "young" and "senior" pediatric surgeons was done on the basis of less than or more than 20 years experience. These 2 groups had almost the same numbers and were subjected to a statistical comparison of their responses.

The distribution of the number of years of MIS experience is shown in Fig. 3. Thirty-nine percent of the respondents fell into the 5 to 10-year category. Eighty-five percent of respondents had more than 5 years experience in MIS, which is an indicator of the extent to which MIS has been incorporated into the pediatric surgical practice. Another indicator of the same is shown in Fig. 4—the proportion of MIS in the operative work. Twenty-three respondents had MIS in the 26% to 50% category and 5 in the more than 50% category. Sixty-one percent of respondents performed more than 10% of their work using MIS. Only 8% of the respondents were not doing any MIS.

The operative load is shown in Fig. 5. This gives an estimate of active practice and therefore the reliability of the operative recommendations given. Eighty-three percent of respondents performed more than 5 operations per week.

2.2. Current status of MIS

The section on current status of MIS was evaluated. Overall recommendations are shown in Table 1. This reflects the overall opinion of a representative group of current pediatric surgeons. The first column represents those actively performing MIS and the second, those who do not do MIS but recommend it. The first and second columns collectively represents the opinion in favor of MIS, whereas the third column represents the voice against MIS for a particular condition. Some respondents did not choose any option for some of the conditions, presumably because it was outside their realm of practice. The lowest number of responses was 100, for reimplantation of ureters. Some conditions, outside the questionnaire, for which MIS was being done, were colectomy, peritoneal dialysis catheters, abdominal lymphangiomas, cecostomy buttons, duplication cyst, pectus repairs, and sympathectomy.

2.3. Comparison between the senior and young surgeons

A comparison of the responses between the young and senior pediatric surgeons was performed and is shown in Table 2. The column "MIS indicated" is the sum of the responses from those who currently perform MIS and those who do not perform MIS but recommend it.

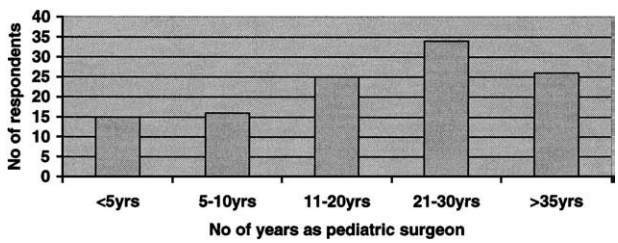

Fig. 2 Experience as a pediatric surgeon.

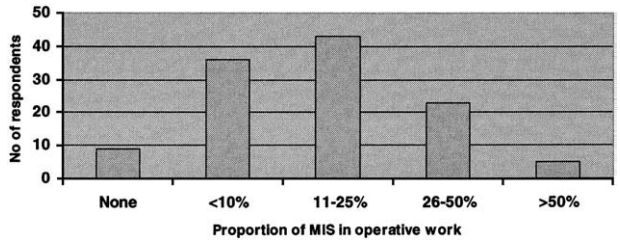

Fig. 4 Minimally invasive surgery in operative work.

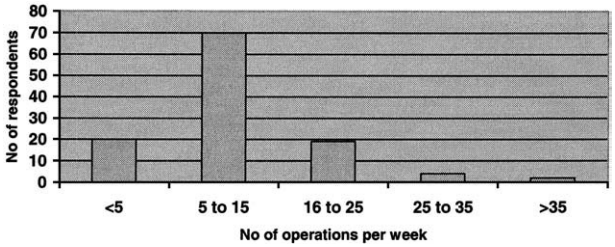

Fig. 5 Operative load of the respondents.

2.4. Role for robotic surgery

The section on future of MIS revolved around robotic surgery and its use in children. Only 20 (17%) of the 116 respondents had previous experience in performing robotic surgery. However, 54% believed that robotic surgery has a role in the future for MIS in children (Fig. 6).

3. Discussion

Two decades after the onset of therapeutic MIS, there is no consolidated statement about the current status of MIS in pediatric surgery by the wider community of pediatric surgeons. Since its initial description in 1923, peritoneoscopy was suggested by many as a reasonable diagnostic and therapeutic modality [1-3]. Lack of technology to adequately miniaturize the instruments was a serious limitation for pediatric use [4]. The introduction of the Hopkins rod lens system and the Storz cold fiber-optic light source in the 1960s was a technological breakthrough that would pave the way for laparoscopy to be integrated into medicine [13,14]. Armed with these innovations that made it possible to miniaturize instruments for use in children, there was a renewal of interest for laparoscopy in children [4]. Evaluation of gonads, differentiation of biliary atresia from

Table 1 Current recommendations for pediatric MIS

No.	Condition	Perform MIS	Recommend MIS	Not indicated [n (%)]	Total responses
1	Inguinal hernia	14	7	95 (82)	116
2	Undescended testis	24	9	83 (72)	116
3	Nonpalpable testis	82	26	8 (7)	116
4	Simple appendicitis	81	21	14 (12)	116
5	Complicated appendicitis	63	13	40 (35)	116
6	Exploration—abdominal pain	76	31	8 (7)	115
7	Ovarian torsion	76	30	9 (8)	116
8	Reduction of intussusception	27	22	67 (58)	116
9	Bowel resection anastomosis	30	24	62 (53)	116
10	Gastrostomy	64	22	30 (26)	116
11	Fundoplication	70	33	12 (10)	116
12	Pyloromyotomy	34	13	69 (59)	116
13	Adhesiolysis	52	22	42 (36)	116
14	Correction of malrotation	21	24	68 (60)	113
15	Cholecystectomy	93	21	1 (1)	115
16	Splenectomy	72	28	15 (13)	115
17	Adrenalectomy	43	53	18 (16)	114
18	Nephrectomy—dysplasia	45	50	17 (15)	112
19	Nephrectomy—Wilms' tumor	5	10	97 (87)	112
20	Heminephrectomy	22	36	50 (46)	108
21	Choledochal cyst	8	24	81 (72)	113
22	Biliary atresia	3	16	95 (83)	114
23	Liver tumors	3	15	95 (84)	113
24	Hirschsprung's—biopsies	64	31	20 (17)	115
25	Hirschsprung's—pull-through	60	31	24 (21)	115
26	Anorectal malformations	38	37	38 (34)	113
27	Pyeloplasty	12	47	45 (43)	104
28	Reimplantation of ureters	4	30	66 (66)	100
29	Bladder/ureteric stone	18	51	32 (32)	101
30	Varicocele correction	48	37	25 (23)	110
31	Achalasia cardia correction	48	41	24 (21)	113
32	Hiatal hernia repair	56	37	18 (16)	111
33	Lung resection	41	42	28 (25)	111
34	Treatment of empyema	71	31	11 (10)	113
35	Diaphragmatic hernia repair	23	25	63 (57)	111
36	Tracheoesophageal fistula repair	8	28	75 (68)	111
37	Mediastinal lesions	29	51	28 (26)	108

Table 2 Comparison of the responses between the young and senior surgeons

No.	Condition	MIS indicated		MIS not indicated		*P*
		Young	Senior	Young	Senior	
1	Inguinal hernia	12	9	44	51	NS
2	Undescended testis	17	16	39	44	NS
3	Nonpalpable testis	55	53	1	7	NS *
4	Simple appendicitis	54	48	2	12	.009 *
5	Complicated appendicitis	46	30	10	30	<.001
6	Exploration—abdominal pain	52	55	4	4	NS *
7	Ovarian torsion	52	55	4	5	NS *
8	Reduction of intussusception	30	19	26	41	.02
9	Bowel resection anastomosis	31	23	25	37	NS
10	Gastrostomy	48	38	8	22	.006
11	Fundoplication	55	49	1	11	.004 *
12	Pyloromyotomy	29	18	27	42	.02
13	Adhesiolysis	43	31	13	29	.005
14	Correction of malrotation	26	19	28	40	NS
15	Cholecystectomy	56	58	0	1	NS *
16	Splenectomy	52	48	3	12	.03 *
17	Adrenalectomy	51	45	5	13	.05
18	Nephrectomy—dysplasia	51	44	4	13	.03 *
19	Nephrectomy—Wilms' tumor	8	7	46	51	NS
20	Heminephrectomy	38	20	14	36	<.001
21	Choledochal cyst	18	14	36	45	NS
22	Biliary atresia	7	12	47	48	NS
23	Liver tumors	8	11	45	49	NS
24	Hirschsprung's—biopsies	49	46	6	14	NS
25	Hirschsprung's—pull-through	46	45	9	15	NS
26	Anorectal malformations	40	35	13	25	.05
27	Pyeloplasty	37	22	14	31	.001
28	Reimplantation of ureters	16	19	33	32	NS
29	Bladder/ureteric stone	34	37	15	15	NS
30	Varicocele correction	47	38	5	20	.002
31	Achalasia cardia correction	49	40	5	19	.003
32	Hiatal hernia repair	50	43	3	15	.004 *
33	Lung resection	46	37	7	21	.005
34	Treatment of empyema	52	50	3	8	NS *
35	Diaphragmatic hernia repair	33	15	19	44	<.001
36	Tracheoesophageal fistula repair	21	15	32	43	NS
37	Mediastinal lesions	41	39	10	18	NS

NS indicates not significant.

* Fisher's Exact test; others χ^2 test; $P < .05$ significant.

hepatitis, search for etiology of ascites and removal of foreign body were successfully tested in children using minimally invasive techniques as early as 1973 [4]. Laparoscopy continued to develop mainly for diagnostic purposes during the next decade. Abdominal pain was shown to be adequately evaluated using laparoscopy [15]. The negative appendectomy rate came down from 10% to 1% using laparoscopy [16]. That apart, use continued for simple procedures such as biopsies of the liver, tumors, and gonads [17]. The 1980s saw the establishment of laparoscopy for therapeutic purposes. Evaluation of undescended testis and clipping of the testicular vessels for a Fowler-Stephens orchiopexy was described [5]. Soon after the performance of laparoscopic cholecystectomy in adults [6], reports came in of the successful performance of cholecystectomy [7]and appendectomy [8] in children. The era after 1990 saw the rapid integration of MIS to all fields of pediatric surgery, so much so that today, it is an integral part of pediatric surgical practice. A few attempts have however been made both previously and in the recent past, to delineate the status of MIS in general surgery and pediatric urology [18-24]. However, a consolidated opinion about the current status of minimally invasive surgery from a wide group of current pediatric surgeons is absent in literature.

The questionnaire method used by our study is adequate for elaborating the current status of MIS. Randomized controlled trials (RCT) will provide the ultimate test of the superiority (or lack of it) for any condition using minimally invasive techniques. However, very few conditions have been studied using RCTs to compare the minimally invasive route with the open route [25-29]. For other conditions where MIS has been reported successfully, every surgeon needs to

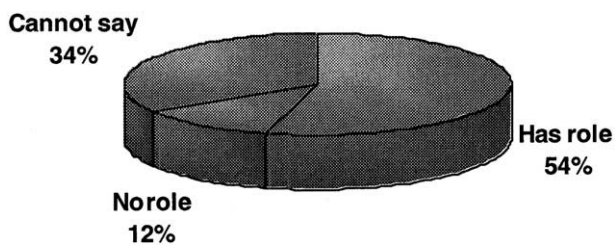

Fig. 6 Predicted role for robotic surgery in children.

still decide whether it should be used for routine practice. When RCTs do not show any difference between the open and the minimally invasive route or when RCTs show conflicting results, what course should the surgeon adopt [27,29,30]? With the burden of performing MIS not just because it can be done, most surgeons are left with the task of making an individual judgment of whether MIS in their hands for a particular patient needs to be done or avoided [31]. This study by elucidating the current status of MIS as voiced by the surveyed pediatric surgeons not only summarizes these opinions, but also provides a statement of the current recommendations for MIS in pediatric surgery.

The summary of the current status as detailed in Table 1 brings out some interesting observations. As pointed out by some of the respondents, it is easy to understand that the clinical status, the availability of facilities, operating time, support from other operating theater staff, and emerging technology will at times determine the indication for MIS in a particular condition. The current practice and overall recommendations are shown in the table. The discrepancy between the columns, "perform MIS" and "recommend MIS" could reflect a number of factors such as lack of training, availability of facilities, lack of support staff, the condition not being part of their chosen specialty (eg, urology), and others. As these factors can vary with time and place, it was not considered for further elaboration in the questionnaire. The sum of the 2 columns however represents the voice for and the third column reflects the voice against MIS. The conditions for which more respondents reported that MIS is not indicated are nephrectomy for Wilms' tumor, biliary atresia, liver tumors, inguinal hernia repair, undescended testis, choledochal cyst, tracheoesophageal fistula repair, reimplantation of ureters, reduction of intussusception, correction of malrotation, pyloromyotomy, diaphragmatic hernia repair, and bowel resection anastomosis. In all the other conditions, more respondents were in favor of MIS. The highest negative response for MIS was for Wilms' tumor nephrectomy (87%) and the lowest was for cholecystectomy (1%). The conditions where more than 80% of respondents favored the MIS route were simple appendicitis, nonpalpable testis, exploration for abdominal pain, ovarian torsion, fundoplication, cholecystectomy, splenectomy, adrenalectomy, nephrectomy for dysplastic kidneys, biopsies for Hirschsprung's disease, hiatal hernia repair, and treatment of empyema. Inguinal hernia is unlikely to become widely popular in children most probably because the advantage gained with the minimally invasive route is perceived to be less. Whereas MIS is the preferred approach for nonpalpable testis, the open route is preferred for the palpable undescended testis. However, it is interesting that 28% of respondents are in favor of MIS even for the palpable undescended testes. Only 1 respondent against MIS for cholecystectomy demonstrates how well the pediatric surgical community has integrated MIS into their recommendations for a procedure that is accepted to be superior with the laparoscopic approach [32]. Although feasibility has been demonstrated in some procedures such as biliary atresia, choledochal cyst, tracheoesophageal fistula, and diaphragmatic hernia repair, most respondents prefer not to use the MIS approach [33-35].

Table 2 differentiates the responses of the young and senior pediatric surgeons. A significant difference in the responses was seen in appendicitis—simple and complicated, reduction of intussusception, gastrostomy, fundoplication, pyloromyotomy, adhesiolysis, splenectomy, adrenalectomy, nephrectomy for dysplastic kidneys, heminephrectomy, pyeloplasty, anorectal malformations, pyeloplasty, achalasia cardia, hiatal hernia repair, lung resection, and diaphragmatic hernia repair. A significantly lesser number of younger pediatric surgeons considered MIS to be a contraindication in each of these conditions. This statistic gives an indication of the evolving recommendations for MIS over the next couple of decades as the senior surgeons retire and young ones take their place. A definite role for robotic surgery as perceived by more than half the respondents also points toward the rapid development of MIS in the days to come.

This survey demonstrates that MIS has been widely incorporated into pediatric surgical practice. Its indications and limitations have been defined as outlined by the current practice and recommendations of the surveyed surgeons. Significant differences exist between the recommendations given by the senior and young surgeons and reflect the trend toward a greater integration of MIS into pediatric surgical practice with time.

Acknowledgments

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