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Cost Comparison between Laparoscopic and Open Appendectomies in Children

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مقارنة بين تكلفة عمليات استئصال الزائدة عن طريق فتح البطن والمناظير عند الأطفال

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الملخص: **الهدف**: . استئصال الزائدة عن طريق المناظير عند الأطفال تعتبر من العمليات المنتشرة والتي تمارس روتينيا في معظم مراكز الرعاية الصحية حول العالم. تكلفة العمليات الجراحية يعد مهم بالنسبة للمرضى ومقدمي الخدمات الصحية. تهدف هذه الدراسة إلى مقارنة التكلفة الإجمالية بين استئصال الزائدة المفتوحة وباستخدام المناظير للأطفال الذين كانوا بحاجة للاستئصال الزائدة بسبب التهاب الزائدة الحاد. تم البحث عن الطرق المناسبة والآمنة ذات التكلفة الفعالة لخفض نسبة هذه العمليات. الطريقة: تم استعراض الملفات الطبية لجميع الأطفال (من سن 0 إلى 12سنة) بمستشفى جامعة السلطان قابوس بعمان الذين احتاجوا لإجراء عمليات استئصال الزائدة عن طريق فتح البطن والمناظير من يونيو 2009 إلى يوليو 2011. **النتائج**: كان استئصال الزائدة بالمناظير فى 75 مريضا بينما كان الاستئصال طريق فتح البطن في 34 مريضا. تم مطابقة العمر والجنس لمرضى عمليات استئصال الزائدة بالفتح والمناظير. كان متوسط وقت العملية 76 دقيقة بالنسبة لاستئصال الزائدة بالمناظير مقارنة مع 49 دقيقة لاستئصال بالفتح ($P < 0.001$) بينما كان متوسط الإقامة بالمستشفى 3.14 بالنسبة لاستئصال الزائدة بالمناظير و 2.15 يوما بالاستئصال بالفتح ($P = 0.08$) كان متوسط التكلفة للعمليتين بالريال العماني 534 بالنسبة لاستئصال بالمناظير و 343 لاستئصال بالفتح ($P = 0.00$). معدل المضاعفات بعد العملية كان أقل بالنسبة لاستئصال الزائدة بالمناظير، غير أن هذا الفرق لم يكن معبر إحصائيا (استئصال بالمناظير 8% مقارنة استئصال بالفتح 11.7%، $P = 0.32$). **الخلاصة**: استئصال الزائدة بالمناظير أكثر تكلفة بالمقارنة بالاستئصال بالفتح ولا يزيد من نسبة المراضة أو طول فترة الإقامة بالمستشفى.

مفتاح الكلمات: التهاب الزائدة؛ استئصال الزائدة؛ التكلفة وتحليل التكلفة؛ عمان.

ABSTRACT: ***Objectives:*** Laparoscopic appendectomy (LA) for children has become very popular and is routinely performed in most health care centres around the world. The cost of surgical procedures is always a concern for patients and health care providers. This study compares, the total cost of open appendectomy (OA) with LA in children who required an appendectomy for acute appendicitis. Suitable and safe cost-effective techniques were also explored to reduce the cost of these procedures. ***Methods***: The medical records of all the children (ranging between 0 and 12 years) at Sultan Qaboos University Hospital in Oman, who required OA or LA from June 2009 to July 2011, were reviewed. ***Results***: LA were performed in 75 patients while OA were done in 34. Patients from the OA and LA groups were age- and gender-matched. The average operative time was 76 minutes for LA and 49 minutes for OA (P <0.001) while the average hospital stay was 3.14 days for LA and 2.15 days for OA (P = 0.08). The average cost of the two procedures was Omani riyals (OMR) 534 for LA and OMR 343 for OA (P = 0.00). The complication rate following procedures was lower in the case of LA, however this was not statistically significant (LA = 8% versus OA = 11.7 %, P = 0.32). ***Conclusion***: LA are costlier procedures than OA, however they are as safe as OA, and do not increase morbidity or the duration of hospital stay.

Keywords: Appendicitis; Appendectomy; Costs and Cost Analysis; Oman.

Advances in Knowledge

- *The insight into the factors responsible for the comparatively higher cost within the laparoscopic appendectomy group is expected to highlight techniques to reduce the cost of laparoscopic appendectomies.*

Application to Patient Care

- *This study demonstrates that laparoscopic appendectomy (LA) is as safe as open appendectomy.*
- *It establishes that the cost of LA can be reduced by certain modifications which will help in reducing health-related costs. Therefore, this study encourages the use of this technique in patients requiring an appendectomy.*

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Pain in the right iliac fossa is one of the most common complaints in the accident and emergency departments of most hospitals.[1] In the paediatric age group, about 50% of such patients undergo an appendectomy with a working diagnosis of acute appendicitis.[2] Therefore, this makes the appendectomy, either laparoscopic appendectomy (LA) or open appendectomy (OA), the most commonly performed emergency procedure in children. For children, the conventional OA has been a gold standard; however, in the last two decades, LA for children has become very popular and routine in most healthcare centres around the world.[1–4]

In the current economic circumstances, the cost of surgical procedures is always a concern for patients and healthcare providers. It has been previously shown that laparoscopic surgery in general is more expensive than the open procedure for the same disease.[1-6] Similarly, there has been debate about the total cost of LA versus OA in children in order to analyse the cost differences between the two techniques.[7,8] Although LA for adults has been practised for the last 7 years at Sultan Qaboos University Hospital (SQUH), it has only become routine for the paediatric age group within the last 3 years, after the Paediatric Surgery Unit was established. While a quantity of Western literature is available on cost comparisons between the two techniques, there has been no such study in the Middle Eastern region to date. In the present study, we compared the total cost of OA and LA in children who required an appendectomy for acute appendicitis, as well as searching for suitable and safe cost-effective techniques to reduce the cost of the procedures in our set-up.

Methods

This retrospective study was conducted in SQUH, Muscat, Oman. The medical records of all the children (ranging in age between 0 and 12 years) who required OA or LA, from June 2009 to July 2011, were reviewed after receiving approval from the Medical Ethics Research Committee of Sultan Qaboos University's College of Medicine & Health Sciences. Demographic data, such as age, weight and gender, were collected from the electronic patient database of SQUH. Other variables recorded were the date of admission, the date and time of surgery, the technique of surgery, the experience level of the operating surgeon, the total theatre time utilised during each technique, the operating time duration, the use of reusable or disposable instruments, the use of postoperative analgaesics and the duration of hospital stay.

The cost of individual consumables used in both techniques was obtained from SQUH's medical supply department. First, we calculated the common costs for OA and LA, based on the cost of the consumables which were the same for each procedure of the same type. For instance, the common costs for OA included the theatre charges and the cost of sutures. For LA, it included the theatre charges, the cost of one ENDOLOOP® ligature (Ethicon, Johnson & Johnson, New Jersey, USA) and the cost of disposable instruments. This last cost varied depending on how many times a disposable instrument was used per appendectomy. The cost of disposable endo scissors and graspers was obtained by dividing the total cost of these items by 3, as they were used up to 3 times a session after sterilisation. However, the cost of disposable trocars was added in full. After obtaining the common costs for each type of procedure, the total cost for each patient was calculated. For OA, the total cost included the OA common cost, the cost of analgaesics and hospital stay [Table 1a]. For LA, the total cost included the LA common cost as well as various other costs where applicable, for instance the cost of CO_2 used, any extra loops or side bags utilised, the use of harmonic scalpels (for the division of the mesoappendix, instead of cauterisation using Maryland forceps), intravenous (IV) analgaesics and the cost of the hospital stay [Table 1b]. The lifespan of reusable instruments for the two techniques is variable, and hence this was not counted in this study.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS), Version 16 (IBM, Chicago, Illinois, USA). Chi-squared (χ^2) tests were used to compare the difference in frequencies of categorical variables. To compare the means of two independent samples, t-tests (for weight, total theatre time and operative time) and non-parametric tests (Mann-Whitney U tests for age, duration of hospital stay and total cost) were used, depending upon the normality of distribution curves. A P value of <0.05 was considered significant.

Table 1a: Cost breakdown of open appendectomies in Omani riyals*

			Cost in OMR
Total cost of OA	Common cost	Theatre charge	312
		Suture material •1 monocryl 3/0 •1 vicryl 2/0 •1 vicryl 3/0	4.67
	Analgaesics cost (per 1 G paracetamol)		1.01
	Hospital stay cost (per day)		12

OA = open appendectomy; OMR = Omani riyals; G = grams.

**In 2012, 1 OMR = 2.59 USD.*

Table 1b: Cost breakdown of laparoscopic appendectomies in Omani riyals*

			Cost in OMR
Total cost of LA	Common cost	Theatre charge	312
		Suction tube	0.91
		Gas tube	3.2
		Camera tube cover	1.616
		Catherisation cost	6.035
		Trocar 11mm	38.4
		5mm†	36.8 x 2
		Endograsper‡	34.5 / 3
		Endodissector‡	29.83 / 3
		ENDOLOOP®	16.833
		1 vicryl J-needle	1.824
		1 monocryl 3/0	2.99
	Additional costs	Side bag	0.615
		Extra ENDOLOOP®	16
		Harmonic scalpel‡	218.25 / 3
		CO_2 (per litre)	0.262
	Analgaesics cost (per 1 G paracetamol)		1.01
	Hospital stay cost (per day)		12

LA = laparoscopic appendectomies; OMR = Omani riyals; mm = millimetres; CO_2 = carbon dioxide; G = grams.

**In 2012, 1 OMR= 2.6 USD; †Two 5mm ports were used; ‡Price was divided by 3.*

Results

In total, 109 patients underwent appendectomies between June 2009 and July 2011; of these, 75 patients were in the LA group and 34 were in the OA group. The male to female ratio of patients was 2:1, and the average age ranged from 6 to 144 months, with a mean of 110.57 ± (standard deviation [SD]) 28.83 months. The average weight was 29.78 ± 11.0 Kg. Preoperative evaluation was done by history-taking, clinical examination, routine full blood count (FBC) and urinalysis for both groups. Further evaluation was done by ultrasonography (USG) and computed tomography (CT) of the abdomen, if the previous evaluation's findings were equivocal.

Patients from the OA and LA groups were age-(OA = 105.15 ± 32.70 months versus LA 113.47± 26.34 months, P = 0.232) and gender-matched (OA = 70% males versus LA 64 % males, χ^2 = 0.45, P = 0.50). The average weight of children in the LA group was significantly higher than of those in the OA group (31.59 Kg versus 26.3, P = 0.01).

The calculated common cost for OA was Omani riyals (OMR) 317 (1 OMR = 2.6 USD) while that for LA was OMR 479. The total costs for individual patients varied depending on the doses of analgesia used (OMR 1.01/1 G of paracetamol) and the duration of their stay in hospital (OMR 12/day). However, the total cost for LA included not only the cost of the analgesia and hospital stay, but also the cost of the extra equipment used (side bags, extra ENDOLOOPS®, harmonic scalpels and CO_2 per litre). The cost for OA ranged from OMR 328 to 381, while that for LA ranged from OMR 491 to 693. The average cost for LA was significantly higher than for OA (LA = 535 ± 42.17; OA = 344 ± 15.12; P = 0.00) [Table 2].

The comparison between the two techniques, regarding other important factors, showed that the total theatre time utilised (in minutes) was 110.38 ± 35.99 for LA and 76.38 ± 17.18 for OA (P <0.001) while actual operative time (in minutes) was 76.53 ± 31.99 for LA and 49.23 ± 16.18 for OA (P <0.001) [Table 2]. As the total operative/theatre time increases, the costs also increase due to factors such as the cost of labour, electricity and equipment. There was no statistically significant difference between the two techniques in terms of the duration of IV analgaesics used (LA = 0.89 ± 1.44; OA = 0.88 ± 1.34; P = 0.97); postoperative morbidity (LA = 8% [6 patients], OA = 11.7% [4 patients], P = 0.32), and duration of hospital stay (LA = 3.14 ± 2.70; OA = 2.15 ± 1.23; P = 0.08).

The complications in the LA group included a bladder injury (n = 1); postoperative fever

Table 2: Comparison of laparoscopic appendectomies with open appendectomies

Variables	Technique of surgery		Statistics
	LA	OA	*P* value
Total theatre time utilised (mins)	110.38 ± 35.99 (SD)	76.38 ± 17.18 (SD)	<0.001
Operative time (mins)	76.53 ± 31.99 (SD)	49.23 ± 16.18 (SD)	<0.001
IV analgaesics (days)	0.89 ± 1.44 (SD)	0.88 ± 1.34 (SD)	0.97
Post-operative morbidity	8% (χ^2 = 9.25)	11.7%	0.32
Hospital stay (days)	3.14 ± 2.70 (SD)	2.15 ± 1.23 (SD)	0.08
Total cost for procedure (OMR)	535 ± 42.17 (SD)	344 ± 15.12 (SD)	0.00

LA = laparoscopic appendectomy; OA = open appendectomy; mins = minutes; IV = intravenous; SD = standard deviation; OMR = Omani riyals.

(n = 1); intestinal intussusception requiring a laparotomy (n = 1); postoperative ileus (n = 1); adhesion obstruction (n= 1), and lower respiratory tract infection (LRTI) (n = 1). In the OA group, complications included postoperative diarrhoea (n = 2); postoperative ileus (n = 1), and LRTI (n = 1).

Discussion

The cost of a laparoscopic appendectomy is an area of great interest in most published literature on the subject.[7,9–11] Although the safety of LA is well documented, the superiority of LA over OA has not yet been established. This is in contrast to laparoscopic cholecystectomies, which have clear advantages over open cholecystectomies.[12]

In this study, we found that LA was more costly than OA. However, the average hospital stay was comparable in both the LA and OA groups, and to those mentioned in the literature.[13,14] Moreover, the duration of IV analgaesics used in the procedures and the rate of postoperative morbidity were similar in both groups. Therefore, the causes of the higher cost in the LA were other than those mentioned above. Significantly longer theatre/operative times [Table 2], and higher common costs (LA = 316.67 *versus* OA = 479.04, *P* <0.001) are probably the causes of the significantly higher cost of LA. Accordingly, an overall reduction in operative time, through utilising more experienced surgeons and by modifying the instruments used, may reduce the cost of LA.

Another point worth mentioning is that although the higher cost of LA is well-established,[10,15] this study found that costs varied considerably within the LA group (OMR 491–693). The cheapest procedure was performed using 3 ports and a single loop on the base of the appendix. In this procedure, the patient in question did not receive IV analgaesics, developed no complications and stayed in the hospital for only one day. In contrast, in another LA procedure, the cost was higher as two loops were used at the request of the surgeon, and the patient suffered a preoperative complication (a urinary bladder injury) and therefore had to stay in the hospital for 14 days. To evaluate the factors responsible for relatively higher cost within the LA group, the analysis was done using a cut-off value of OMR 535 (the mean cost value). The analysis revealed that the factors which significantly increased the cost of the procedure were the use of harmonic scalpels (χ^2 = 10.01; *P* = 0.002), longer operative times (>80 minutes, χ^2= 9.87; *P* = 0.002), and duration of hospital stay (>2 days, χ^2 = 25.24, *P* <0.001). As mentioned previously, longer operative times increase the cost of the procedure due to the increased cost of labour. The use of harmonic scalpels in LA is also expensive; division of the mesoappendix can be performed less expensively by cauterising using Maryland forceps. A longer hospital stay increases the cost for the same reason as longer operative times. In this study, one of the reasons for longer hospital stays was the set protocol of giving IV antibiotics for 5 days to patients who had complicated appendicitis; this set protocol has currently been modified to reduce the length of hospital stays.

Recently, the Paediatric Surgery Unit at SQUH has improved current practices in many ways. The average operative time (in minutes) has been reduced from 85 in the first year to 76 in the second year. Additionally, almost all of the patients are now started on oral analgaesics once they are fit to take analgaesics orally. Moreover, most of the patients, barring any complications, are currently discharged from the hospital on their first postoperative day.

Although the above mentioned measures are expected to decrease the cost of LA in the near future, we feel that certain other modifications are still needed to make the existing techniques of LA more cost-effective. For example, the results of two ports[15,16] or a single 'all-in-one' port appendectomies are promising, as reported by Visnjic *et al.* and Stylianos *et al.*[11,17] As these studies demonstrate, the cost of a single port appendectomy is less than that of an appendectomy using 3 ports. Similarly, the use of a single ENDOLOOP® or endo stapler,[18] and avoiding the use of harmonic scalpels, are other possible ways to reduce the cost of LA. The use of an endo stapler with polymeric clips has been shown to be safe, as well as reducing operative time.[18] Appropriate patient evaluations and same day discharges may also help to reduce the duration and cost of hospital stays.[19,20]

Conclusion

An LA is a costlier procedure than an open appendectomy, however it is as safe as an open appendectomy, and does not increase patient morbidity or the duration of hospital stay. Certain modifications to the standard existing technique, such as equipment substitution or economy, should be undertaken in order to reduce the overall cost of LA.

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