MANAGEMENT OF ACUTE APPENDICITIS IN THE NEW MILLENNIUM

KLAAS IN'T HOF

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MANAGEMENT OF ACUTE APPENDICITIS IN THE NEW MILLENNIUM

Behandeling van appendicitis acuta in het nieuwe millennium

Proefschrift

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INTRODUCTION

The prevalence of acute appendicitis in The Netherlands is 16460 times a year, 8647 man and 7813 women in 2006 and is still increasing. The chance of undergoing an appendectomy is higher in women than in men, 23 versus 12 percent, this is in contradiction with the chance of developing acute appendicitis, 7 versus 9 percent, due to the number of incidental and unnecessary appendectomies. In spite of the high incidence of acute appendicitis the percentage appendices without signs of inflammation during surgery remains high, between 5% and 30%. These data show the challenge to the clinician to diagnose acute appendicitis. Adjacent to this are the costs involved with the diagnosis and treatment representing a returning point of discussion.

The mean costs of negative appendectomy are 2712 Euro, also the complication rate is relatively high: six percent. The new health care system (DBC) in The Netherlands is implemented to reduce costs and have a manageable system. In this health care system the counted insurance costs of laparoscopic appendectomy are slightly higher than the costs of open appendectomy. However the costs of negative appendectomy can be saved by optimizing the preoperative workup and avoiding unnecessary appendectomies. One of the arguments to choose for open appendectomy is represented by the lower direct costs. Otherwise laparoscopy is pre-eminently suitable for diagnostic purpose and the appendix can left in situ in case of a normal appendix, avoiding the possible complications and costs of appendectomy. Computer Tomography (CT) has proven to be a reliable non-invasive diagnostic tool, although discussion is still going on about the most accurate CT technique and about the exposure of radiation to the patients. However in The Netherlands in daily practice CT is not often used resulting in a high percentage of unnecessary appendectomies, especially in fertile women. The discussion remains if this is justified. Arguments used to avoid CT are costs, radiation exposure and good quality of ultrasonography. Implementation of CT in daily practice can also be limited by the learning curve of the radiologist. Especially in hours of duty, the quality of CT diagnosis can be less sufficient. One of the last questions is whether histopathology of the inflamed appendix without other macroscopic abnormalities is necessary. In literature primary malignancy of the appendix is reported to be rare. Carcinoid tumors of the appendix are the most common single appendicular malignancies, with a prevalence of 0.3-0.9 percent of patients undergoing appendectomy. This thesis tries to make treatment of patients suspected of acute appendicitis tailor made.

OUTLINE OF THIS THESIS

In **chapter 2** the question is answered if *unenhanced CT can be used as a diagnostic tool in patients with suspected acute appendicitis.* Due to the conclusions of chapter 2 the question if

a *learning curve can withhold implementation of the unenhanced helical CT in daily practice* is answered in **chapter 3**. To assess evidence for the *optimal CT technique* to analyze adult patients with suspected acute appendicitis a literature review of the last decade was performed in **chapter 4**. As mentioned in the introduction the cost effectiveness of the health care system is a major point of interest of society. In discussions about laparoscopic surgery techniques higher costs are used as a disadvantage. In **chapter 5** the real *costs of open and laparoscopic appendectomy* are described. Following the need for minimal invasive surgery in the society we studied the aim for *one-trocar appendectomy* in daily practice in a single hospital in **chapter 6.** In **chapter 7** the *operative technique of laparoscopic appendectomy* is described in dedication of the editor from the author's personal experience. If *histopathology is necessary after removing an inflamed appendix* is described in **chapter 8**. **Chapter 9** gives a summary and conclusion followed by a Dutch summary in the last chapter.

Chapter 2

Surgical validation of unenhanced helical CT in acute appendicitis

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ABSTRACT

Introduction: Surgery for pain in the right lower quadrant of the abdomen remains a clinical dilemma. This prospective study assessed the accuracy of preoperative unenhanced helical computed tomography (CT) in the evaluation of patients with suspected acute appendicitis.

Patients and methods: One hundred-and-three adult patients, with suspected acute appendicitis underwent unenhanced helical CT of the abdomen. Subsequently, all patients underwent laparoscopic inspection of the abdominal cavity by a surgeon who was blinded to the diagnosis suggested by CT. Patients underwent appropriate surgical therapy accordingly. Follow-up was at least 6 weeks.

Results: Appendicitis was diagnosed by CT in 83 patients (80.5 per cent). Acute appendicitis was identified during laparoscopy in 87 patients (84.5 per cent). Prospective interpretations of CT images yielded a sensitivity of 95.4 per cent, and a specificity of 100 per cent for the diagnosis of acute appendicitis. There were four false-negative scans. In 12 of 20 patients without signs of appendicitis on CT, the scan established the presence other pathology was. At operation no additional pathology was observed in this group and all other diagnoses proved to be correct.

Conclusions: Plain helical CT in patients suspected of acute appendicitis provides an accurate diagnosis without the disadvantages of contrast enhancement.

INTRODUCTION

Acute appendicitis affects over 700,000 patients annually in the European Community, 16,000 in the Netherlands [1]. A similar number of patients with suspected appendicitis are hospitalised with a subsequent diagnosis other than appendicitis [2].
At least 20 per cent of appendicectomies should be considered unnecessary, because other or no pathology is found at operation [3,4]. However, surgical tradition dictates removal of the appendix whenever a gridiron incision has been made at open surgery. Diagnostic laparoscopy has been shown to improve diagnostic accuracy for acute appendicitis, and to reduce the number of redundant appendicectomies, both in fertile women (by 17-38 per cent) and also in men (by 11 per cent)[4-9]. Preoperative computed tomography (CT) in patients suspected of acute appendicitis has also been demonstrated to be highly accurate in confirming or ruling out acute appendicitis [10].
Several studies on the value of CT in acute appendicitis have been performed with administration of contrast, either intravenously and/or in the digestive tract. The present study, was a prospective assessment of the accuracy of preoperative helical CT without contrast in confirming or excluding acute appendicitis and other pathology in patients with acute right lower quadrant pain.

PATIENTS AND METHODS

The study included 103 consecutive patients over 16 years of age with suspected acute appendicitis who presented to the emergency departments of the University Hospital Rotterdam and Medical Centre Rijnmond-Zuid between December 1999 and November 2000. The clinical diagnosis was established by senior surgeons in all patients. All patients were scheduled for emergency laparoscopy. Before operation each patients gave written informed consent and subsequently underwent abdominal CT. The study was approved by medical ethical committees of both participating hospitals.
Preoperative evaluation included medical history, physical examination, and laboratory tests, including pregnancy tests if appropriate, all at the discretion of the surgeon. Exclusion criteria were signs of acute bowel obstruction, contra-indication to laparoscopy, contra-indication to general anaesthesia or pneumoperitoneum, age under 16 years, pregnancy and sepsis. Sepsis was defined as a body temperature of 39 ^{0}C or above or 35.5 ^{0}C or less and dependence on catecholamines to maintain normal blood pressure, or positive blood cultures. Signs of acute pancreatitis or acute aneurysm of the abdominal aorta or iliac arteries on CT were considered to be stopping points.
CT scans was performed within 1 h of being requested. A LightSpeed Advantage™ scanner (GE Medical Systems, Milwaukee, Wisconsin, USA) was used to obtain a single breath-hold

helical scan from the caudal edge of the T11 vertebral body to the pubic symphysis. A 7.5-mm beam collimation was used for the upper abdomen to the anterior iliac spine, and a 5 mm beam collimation was used for the lower abdomen to the pubic symphysis. the table speed was 10 m/sec (11.25 mm / rotation, pitch 2.0, 120 kV, 190 mAs). No intravenous, oral or rectal contrast was used.

The primary sign on CT for the diagnosis acute appendicitis was dilatation of the appendix greater than 6 mm in transverse diameter. Secondary signs were periappendiceal infiltration, thickening of the caecal wall, presence of an appendicolith, periappendiceal phlegmon or abscess, and adenopathy. If only positive secondary signs were present, te scan was considered positive for acute appendicitis. After completion of scans, a radiology resident and/or a senior radiologist reviewed the images. Their findings were noted on a record form for use by the surgeon after the diagnostic laparoscopy (see below). At the completion of the study, all scans were reviewed by an expert radiologist who was blinded to the clinical history and surgical findings. His scores were used to evaluate the final performance of preoperative CT.

After CT, all patients underwent a standardized diagnostic laparoscopy, which included inspection of the gallbladder, stomach, duodenum, sigmoid, transverse and ascending colon, distal 100 cm of ileum and internal genitals if applicable. The lesser sac was not routinely opened to allow inspection of the pancreas. The surgeon was blinded to the CT findings during laparoscopy until the explorative phase of the laparoscopy was considered complete, at which point the laparoscopic findings were noted on a record form. These findings were considered the 'gold standard', and were used to interpret the value of preoperative CT. Subsequently, the surgeon was free to use any extra information provided by CT in clinical decision making. Patients were treated with respect to the final diagnosis, non-surgically or by open or laparoscopic surgery. Non-inflamed appendices were not removed if treatment was laparoscopically. All removed specimens were sent for pathological examination.

Follow-up involved completion of postoperative record forms 1 and 2 days, and 1 and 6 weeks after surgery. Other data collected included hospital stay, pathological diagnosis, complications and change of diagnosis and treatment after discharge.

RESULTS

Sixty-four men and 39 women, ranging in age from 16 to 82 (median 36) years were enrolled in this study. During the study period no patients meeting inclusion criteria were excluded. Prospective interpretation of unenhanced helical CT images had a sensitivity of 95.4 per cent and a specificity of 100 per cent for the diagnosis of acute appendicitis. The appendix was demonstrated in all scans. There were no false positive and four false negative CT interpretations. In patients with false negative interpretation, acute appendicitis was demonstrated during laparoscopy.

Acute appendicitis was diagnosed by CT in 83 patients (80.6 per cent). Whereas 87 patients (84.5 per cent) were diagnosed with acute appendicitis during laparoscopy (Table 1). Laparoscopic appendectomy was intended in all patients with signs of acute appendicitis during laparoscopy, but three patients eventually underwent open appendectomy for technical reasons. All 87 removed appendices were inflamed on microscopic examination.

No appendicitis was diagnosed on CT scans in 20 patients (19.4 per cent). No pathology was revealed by CT in eight of these patients, but four were subsequently diagnosed with acute appendicitis during laparoscopy. Three cases of acute appendicitis involving only the tip of the appendix, and one of perforated appendicitis with micro-abscess were misdiagnosed by CT. Laparoscopy revealed no abdominal pathology in the other four patients.

Other pathology was observed on the CT in the remaining 12 patients without signs of appendicitis on CT. No additional pathology was found at operation and the diagnosis based on CT findings was correct. The radiological record form was used by the surgical team in six instances. In five patients no diagnosis could be found during laparoscopy which was confirmed by a negative CT scan. In one patient with a negative laparoscopy, pyelonephritis was diagnosed by CT.

Table 1 Laparoscopic and radiological characteristics of 103 consecutive patients suspected of acute appendicitis

	CT scan	Laparoscopy
appendicitis	83	87
no appendicitis	20	16
no pathology	8	5
gastric perforation	1	1
ileitis	2	2
colitis	1	1
enteritis	1	1
cecal infiltration	1	1
dermoid cyst	1	1
ileus	1	1
infiltration sigmoid	3	3
pyelonephritis	1	0
total	103	103

A gastric perforation in one patient was sutured laparoscopically. Two patients with ileitis, one with colitis, one with enteritis, and one with mild infiltration of the caecum were treated conservatively. One patient with a dermoid cyst and one with a mild ileus of unknown origin were also treated non-operatively. Three patients were diagnosed with infiltration of the sigmoid wall, one of them underwent a Hartmann's procedure for perforated adenocarcinoma of the

sigmoid. Two patients were diagnosed with diverticular disease of the sigmoid during laparoscopy. their initial treatment was conservative, but one had a sigmoid resection after three months because of continuing obstructive complaints. One patient recovered completely and showed no tumour on colonoscopy and control CT after three months. The patient with pyelonefritis diagnosed by CT was treated with antibiotics. No laparoscopic procedure was converted to laparotomy because no specific diagnosis could be found laparoscopically.
In 11 patients (10.7 per cent) diagnostic laparoscopy was not followed by surgical treatment, in two patients because no signs of appendicitis or other pathology were shown during laparoscopy and in nine patients with various diagnoses as noted above.
Follow-up was at least 6 weeks for all patients. Directly after surgery, and at 6 weeks' follow-up, no patients had been diagnosed with additional pathology. Six patients had complications. Three patients with wound infections were treated by local wound drainage and two patients who developed an intra-abdominal abscess were treated successfully by percutaneous drainage under ultrasonographic guidance. One 57-year-old woman who developed tertiary peritonitis and enterocutaneous fistula after sigmoid resection for perforated sigmoid adenocarcinoma stayed in the hospital for 9 months. There were no deaths. Mean hospital stay was 2.8 (median 2 days) days, excluding the patient with perforated carcinoma of the sigmoid, who stayed in hospital for 82 days.

DISCUSSION

In the Western world, the lifetime risk of acute appendicitis is 6.7 per cent for females and 8.6 per cent for males [11]. However, the lifetime chance of appendectomy is higher, 23.1 and 12 per cent respectively [11]. This discrepancy reflects the number of incidental and unnecessary appendectomies. Removing a normal appendix is associated with an early complication rate of 6.7-13 per cent and a late complication rate of 4 per cent in the early years after surgery[12,13].
Several imaging techniques have been advocated to improve the diagnostic accuracy in patients suspected of acute appendicitis. The introduction of CT in clinical decision making has been shown to decrease the rate of negative appendectomies in this group of patients [10,14]. A sensitivity and specificity of 90.1 -97 per cent and 94.1-100 per cent respectively have been reported for CT [15,16]. This modality has been shown to be superior to ultrasonography in providing an adequate diagnosis in patients with possible acute appendicitis at the cost of a mild dose of ionising radiation [16-19].
The optimal CT technique is still under debate[20]. Several techniques, ranging from plain abdominal CT to thin section enhanced helical CT with oral and rectal contrast focussing on the appendix have been advocated [10,14,19,20-22]. Many studies that have attempted to evaluate specific CT techniques are flawed because they are either retrospective in design or use clinical follow-up to verify the final diagnosis in part of the study group, or both. In this study, the

value of unenhanced helical CT without rectal or oral contrast was prospectively evaluated by comparing CT findings with findings at diagnostic laparoscopy in all patients. The implications of introduction of routine preoperative CT with respect to the requirement for 24-h availability of radiological expertise and interobserver variability were not investigated. In daily practise those items are of paramount importance and should be addressed in further studies.

Laparoscopic inspection of the abdominal cavity enables the surgeon to diagnose acute appendicitis accurately[23]. In this study it was considered the 'gold standard' in providing the diagnosis in patients with suspected acute appendicitis. This assumption proved to be correct because no patients required conversion to laparotomy purely for diagnostic purposes. Unenhanced CT without oral or rectal contrast yielded a high sensitivity and specificity of 95.4 and 100 per cent respectively for acute appendicitis. This method therefore represents a simple, rapid and relatively inexpensive technique with which to obtain an accurate diagnosis in patients with suspected acute appendicitis without possible allergic effects or patient discomfort related to the use of intravenous or enteral contrast. Avoiding contrast enhancement also has an economic cost advantage; in authors'departments, use of intravenous and rectal contrast forms 25 percent of the total costs of CT.

Unenhanced CT without oral or rectal contrast was also able to diagnose other pathology accurately in this group of patients. Pre-operative CT could therefore provide information on the optimal surgical access to the abdomen in case of unexpected diagnoses such as gastric or sigmoid perforation that require a surgical approach other than a McBurney incision. In laparoscopic surgery, preoperative information on the exact location of the appendix or other intra- abdominal pathology is of less value because laparoscopy allows easy inspection of the entire abdominal cavity.

In this study, both men and women benefited from pre-operative CT ; a McBurney incision would have been prevented in 9 women (23.0 per cent) and five men (7.8 per cent) if the intended treatment would have been changed on the basis of CT findings. Introducing diagnostic laparoscopy in the standard work-up of patients with suspected acute appendicitis deprives preoperative CT of some of its benefits because it diagnosed 99 per cent accurately in this study and many conditions encountered, including acute appendicitis and gastric perforations, can be treated laparascopically. As a purely diagnostic modality, however, it is inferior to CT because it is more invasive. This is particularly disadvantageous to patients with a non-surgical disease. However, early laparoscopy in patients with acute non-specific abdominal pain is associated with a higher accuracy and improved quality of life compared with close observation followed by surgical intervention if signs of peritonism develop[24].

The four false negative CT interpretations, particularly the missed case of perforated appendicitis, are of great concern. Reducing the collimation used in the appendiceal region (for example from 5 to 3.25 mm) might improve the accuracy, as only the tip of the appendix was affected in three of four with a false-negative scan. Reading the scans directly on the work station might also improve interpretation.

Rao et al. [10] showed in a North American study that routine contrast-enhanced appendiceal CT in patients with suspected acute appendicitis not only improved patient care but also reduced the use of hospital resources. In the light of the present finding that unenhanced helical CT can give an accurate diagnosis without the disadvantages of contrast enhancement, a randomized trial comparing its costs with those of diagnostic laparoscopy is now required.

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Chapter 3

Interobserver variability in computed tomography scan interpretation for suspected acute appendicitis

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ABSTRACT

Objective: This prospective study assessed the interobserver variability of Computed Tomography (CT) scan interpretation in patients with suspected acute appendicitis.

Patients and methods: One hundred-and-three adult patients with suspected acute appendicitis underwent unenhanced helical multi slice CT of the abdomen. Subsequently, all patients underwent laparoscopy by a surgeon who was blinded to the diagnosis suggested by CT. All CT scans were interpreted by group A, B, and C radiologists with different levels of expertise.

Results: Acute appendicitis was diagnosed on multi slice CT in 69 %, 74% and 80% by group A, B, and C radiologists respectively. At laparoscopy, 83% of patients were diagnosed with acute appendicitis. Specificity of CT for the diagnosis acute appendicitis by group A, B and C radiologists were: 94%, 94% and 100% respectively. Sensitivity was: 81%, 88% and 95% respectively. The positive predictive value was respectively 98.6, 98.7 and 100%. The negative predictive value respectively 50, 68 and 81%. Differences in proportion of positive outcomes between observer groups A and C differed significantly (p=0.035). During laparoscopy 12 patients were diagnosed with other diseases. These were all correctly diagnosed by group C; group A and B both missed the diagnosis colitis in one patient, all other disorders were diagnosed correctly.

Conclusions: Sensitivity of CT interpretations for the diagnosis acute appendicitis differs considerably between radiologists. This interobserver variability has to be taken into account during implementation of routine CT scanning in patients with suspected acute appendicitis. Only in centers with expert CT radiologists the implementation of routine CT scanning in patients with suspected acute appendicitis is justified

INTRODUCTION

Diagnosing acute appendicitis remains a challenge to the clinician. More than 15 per cent of appendectomies are performed unnecessarily while in some high-risk populations, such as women of reproductive ages, the population-based rate of unnecessary appendectomies is as high as 26 per cent [1]. Preoperative imaging techniques, such as computed tomography (CT) and ultrasonography (US) have been shown to improve diagnostic accuracy in patients with suspected acute appendicitis [2,3,4,5,6]. In centers with dedicated expertise, sensitivity and specificity of over 95 per cent in patients with suspected acute appendicitis have been reported using either technique [2,3,4]. In the majority of studies investigating the value of different preoperative imaging techniques, the expert interpretation of the images is provided. However, patients with acute illnesses such as appendicitis present at any time of the day and require prompt and accurate diagnosis and treatment. Consequently, the assessment of patients with suspected acute appendicitis and interpretation of US and CT scans is in the hands of in house staff. These health care professionals might have limited expertise in diagnosing appendicitis by US or CT. To assess the interobserver variability of CT scan interpretation in patients with suspected acute appendicitis, a prospective study was performed.

SUBJECTS AND METHODS

From December 1999 until November 2000, a prospective study was performed in a cohort of 103 consecutive patients over 16 years of age, suspected of acute appendicitis. All patients presented to the emergency departments of a tertiary care hospital (Erasmus University Medical Center) or in community teaching hospital, the Medical Center Rijnmond Zuid in Rotterdam, The Netherlands. Institutional review boards inclusive an ethical committee of both participating hospitals approved the study. Clinical suspicion of acute appendicitis was established by staff surgeons in all cases as described before [4]. All patients were scheduled for emergency laparoscopy. Prior to surgery all patients signed informed consent and subsequently underwent non-contrast abdominal multi slice CT. All CT scans were obtained within one hour after being requested by using a helical CT scanner (LightSpeed Advantage™; General Electrics Medical Systems, Milwaukee, Wisconsin, USA). A single breath-hold helical scan from the caudal edge of the 11th thoracic vertebral body to the pubic symphysis was obtained. A 7.5mm beam collimation was used for the upper abdomen to the anterior iliac spine, and a 5mm beam collimation was used for the lower abdomen to the pubic symphysis. A table speed of 10 m/sec (11.25mm / rotation) was used (pitch 2.0; 120 kV; 190 mAs). In doubt reformatted images were obtained. Exclusion criteria were signs of acute bowel obstruction, contra-indications to laparoscopy, general anesthesia or pneumoperitoneum, age less than 16 years, pregnancy and sepsis. Sepsis was defined as body temperature >39^{0}C or <35.5^{0}C and

dependence on catecholamines to maintain normal blood pressure or positive blood cultures. Signs of acute pancreatitis or acute aneurysm of the abdominal aorta or iliac arteries on CT were considered stopping points.

Image interpretation All CT scans were reviewed by three different groups of radiologists. Promptly after completion of the CT a radiology resident, trained in computer tomography interpretations, interpreted the images (Group A). These findings were recorded. Subsequently, a staff radiologist on call blinded to the first findings reviewed the same images and noted these findings on a second blank record form (Group B). This last record was available to the surgeon upon completion of the diagnostic laparoscopy (see below). An expert abdominal radiologist (GPK) who was blinded to the clinical history, earlier CT evaluations and surgical findings (Group C) reviewed all scans.

The primary sign on CT establishing the diagnosis acute appendicitis was dilatation of the appendix greater than 6mm in transverse diameter. If this signs was present, the CT was considered 'positive'. Secondary signs were thickening of the cecal wall, periappendiceal infiltration, presence of an appendicolith, periappendiceal phlegmon or abscess, collection of air bubbles in the lumen of the appendix and lymphadenopathy. If two or more secondary signs were present, the CT was also considered 'positive'. If only one secondary sign was present, the CT was regarded as 'negative'. If no signs were present, the CT was interpreted as 'negative' as well.

Laparoscopy After CT, all patients underwent a diagnostic laparoscopy. All laparoscopic inspections were supervised or performed by staff surgeons. The surgical team was blinded to the CT findings during surgery until the explorative phase of the laparoscopy was considered complete. At that time the surgeon noted the laparoscopic findings on a record form. These findings were considered the 'gold standard' and were used to interpret the value of preoperative CT scanning.

Subsequently, the surgeon was free to use any additional information from the CT in clinical decision-making. Patients were treated with respect to the final diagnosis, either non-surgically or surgically, open or laparoscopically. Normal appendices were not removed. All removed specimens were sent for pathological examination.

Statistics To compare differences in performance between observer groups A, B, and C, sensitivity, specificity and positive(ppv) and negative(npv) predictive value were calculated. Level of agreement between groups was expressed by kappa values. The kappa coefficient of reliability provides a pair wise proportion of agreement between or among observers, corrected for chance. To test differences in proportion of positive outcomes between observer groups A, B, and C, McNemar's test was used. P-value's <0.05 were considered significant.

RESULTS

Sixty-four males and 39 females, ranging in age from 16 to 82 years (median 36 years) were enrolled in this study. During the study no patients meeting inclusion criteria were excluded. Group A and C radiologist interpreted all CT scans while group B radiologist interpreted hundred CT scans. Interpretation of scans by group A, B and C radiologists showed considerable differences (Table). Acute appendicitis was diagnosed on CT in 69 per cent, 74 per cent, and 80 per cent by group A, B, and C radiologists respectively. At laparoscopy, 83 per cent of patients were diagnosed with acute appendicitis. No laparoscopic procedures were converted to laparotomy for diagnostic purposes.

The level of agreement (kappa) was good, 0.76 and 0.70 respectively between group A and B and between group B and C radiologists, but less between group A and C: 0.57. Specificity of CT interpretations for the diagnosis acute appendicitis in these 103 patients by Group A, B and C radiologists was comparable: 94 per cent, 94 per cent, and 100 per cent respectively (Table). However, sensitivity differed considerably between groups: 81 per cent, 88 per cent, and 95 per cent respectively. There were 16, 8, and 4 false negative and 1, 1 and 0 false-positive CT interpretations in group A, B, and C respectively. Differences in proportion of positive outcomes between observer groups A and C differed significantly (p=0.035). The ppv was respectively

Table 1 Accuracy of CT interpretations by group A, B, and C radiologists as compared to laparoscopy

	Group A	Group B	Group C	Laparoscopy
cases (n)	103	100	103	103
appendicitis (n)	71	74	82	87
no appendicitis (n)	32	26	21	16
no pathology	21	15	8	5
gastric perforation	1	1	1	1
ileitis	2	2	2	2
colitis	0	0	1	1
enteritis	1	1	1	1
cecal infiltration	1	1	1	1
dermoid cyst	1	1	1	1
ileus	1	1	1	1
infiltration sigmoid	3	3	3	3
pyelonephritis	1	1	1	0
specificity	94%	94%	100%	
sensitivity	81%	88%	95%	
# false negative	16	8	4	
# false positive	1	1	0	

98,6 per cent, 98,7 per cent and 100 percent. The npv respectively 50 per cent, 68 per cent and 81 per cent. During laparoscopy 12 patients were diagnosed with other diseases (Table). The expert radiologist (i.e. group C) correctly diagnosed these other diseases in all patients; group A and B radiologists both missed the diagnosis colitis in one patient, all other disorders were diagnosed correctly. Pathology confirmed surgical findings in all cases. Follow-up was at least six weeks for all patients. Directly after surgery and at six weeks' follow-up, no patient had been diagnosed with additional pathology.

DISCUSSION

Morbidity associated with unnecessary appendectomies varies from three to six percent [7,8]. Particularly long-term complications such as bowel obstruction due to adhesions or incarcerated incisional hernias carry considerable risk and economical burden. In several studies clinical and economical correlates of misdiagnosed acute appendicitis in the United States have been assessed [5,9]. This study of Flum showed that in 1997 in the United States, 15.3 per cent of 261,134 non-incidental appendectomies were negative for acute appendicitis. The authors estimated that $741.5 million in total hospital charges resulted from admissions for unnecessary appendectomy. In our study, all patients were scheduled for emergency laparoscopy after they were diagnosed with acute appendicitis by a senior surgeon. Even in this group of patients with a high index of suspicion, 17 per cent did not have acute appendicitis at laparoscopic evaluation.

To decrease the number of unnecessary appendectomies, several imaging techniques such as CT and US have been advocated to improve diagnostic accuracy. Introduction of CT in clinical decision-making has been shown to decrease the rate of negative appendectomies [2,5,6,10,11]. Sensitivity and specificity rates of 90.1 -97 per cent and 94.1-100 per cent respectively have been reported for CT [2,4]. However, these high accuracies involve studies under optimal conditions with experts interpreting CT images. Under these conditions CT has been shown to be superior to US in providing an adequate diagnosis in patients with suspected acute appendicitis [12,13]. Interobserver variability in US for establishment of acute appendicitis is great because accurate ultrasonographic recognition of an inflamed appendix requires outstanding expertise in abdominal ultrasonography. Therefore, US have never been adopted routinely to diagnose appendicitis although US plays a role in pregnant women and children who have a thin abdominal wall that renders US more feasible [13]. The quality of CT images is far less dependent on the observer. However, this study shows that the interpretation of CT images carries a considerable interobserver variability. Although a positive CT is rarely erroneous, false-negative CT interpretations are more common when less experienced assessors review the images. In one study Albanos et al find no differences between resident and faculty interpretation of CT scans in the evaluation of acute appendicitis[14]. The training

of the residents in the albanos study and the awareness of the preliminary reports can explain this. It seems likely that there is also a big difference in patient selection; there are only 33 patients with acute appendicitis in the Albanos study this can maybe influence the interpretation. The interobserver variability in CT scan interpretation for suspected acute appendicitis has its consequences for training of medical doctors who are involved in the care of patients with right lower abdominal quadrant pain. Integration of interpretation of CT images into the early training of radiologist, surgeons and emergency doctors is a serious consideration. Telesupervision of image interpretation is increasingly adopted and will become the standard of care in the near future. Information technology allows and will oblige the medical community to provide the highest degree of expertise at any time and any place. However, also in expert hands, false-negative CT interpretations do occur. In this study the expert radiologist interpreted four CT scans falsely negative. Reducing the collimation as used in the appendiceal region (for example from 5 to 3.25 mm), reading the scans directly on the working station might improve the quality of interpretation[16]. Administering intravenous or enteral contrast in difficult cases might improve the quality of interpretation although only one prospective study showed a significant superiority of contrast CT scanning for the diagnosis of acute appendicitis [15]. Nevertheless clinical assessment will continue to play a role. Clinical or outpatient observation and diagnostic laparoscopy are to be considered in those patients with negative CT scans.

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Chapter 4

A metaanalysis to determine the optimal computer tomography scanning technique in patients with suspected appendicitis

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Submitted

ABSTRACT

Background. Conflicting opinions exist with respect to the optimal computer tomography scanning (CT) technique to diagnose acute appendicitis. A review of the literature was performed to answer this question.

Methods. A systematic search of literature was performed to identify clinical trials on CT scanning in patients with suspected acute appendicitis. Data were pooled into different groups: with (enteral and intravenous) or without contrast enhancement. A method of bivariate meta-analysis was used to analyze data. This method simultaneously estimates the pooled sensitivity and specificity, taking the correlation between these two into account, as well as heterogeneity between studies. Pooled data were also used to calculate negative and positive predictive values.

Results. Eighteen studies were identified, including 2207 patients, 658 patients underwent CT scanning with enteral contrast enhancement, 474 with intravenous (iv) contrast and 1089 without contrast. The only significance difference in sensitivity was found between iv contrast CT scanning and non contrast CT scanning; 0.97(95%CI:0.93-0.99) and 0.92(0.87-0.95) respectively (p=0.04). Specificity was comparable between the 3 groups; enteral 0.96(95%CI:0.91-0.98), iv 0.92(0.85-0.96) and in the non contrast group 0.92(0.86-0.90). Negative predictive value was higher in the contrast groups: 95% in the enteral group, 95% in the iv group and 87% in the non contrast group. The positive predictive value was comparable in the 3 groups (95%,94% and 94%).

Conclusion. The existing evidence suggests that CT scanning with intravenous contrast enhancement is the preferred technique in patients with suspected acute appendicitis.

INTRODUCTION

Negative explorations for presumed acute appendicitis are common. Still 7.6% to 42% of operations are deemed unnecessary because the appendix appears normal at exploration [1,2]. Preoperative computer tomography (CT) scanning has been shown to decrease the rate of negative abdominal explorations in these patients, to decrease perioperative complications and to be cost effective [2,3]. However discussion still exists about the optimal CT protocol: whether or not to use contrast enhancement and if so which contrast route has to be preferred. Most authors propagate the use of contrast enhancement because of the assumed decrease in the number of false negative diagnoses and improvement of the appraisal of the appendix [4,5,6]. However, use of contrast has potential disadvantages like allergic reactions, increased radiation exposure when combined with multiphasic imaging and higher costs. Use of unenhanced helical CT scan has been shown to provide excellent accuracy in patients with suspected acute appendicitis [7,8]. The aim of this study was to assess evidence from the literature for the optimal CT technique to analyze adult patients with suspected acute appendicitis.

MATERIALS AND METHODS

We searched Medline for English literature published from January 1997 until May 2008 with key words: computer tomography, acute appendicitis, contrast agent, unenhanced, enhanced. The search was restricted to English literature, titles, abstracts and adults. Surgery and/or clinical follow up were used as reference standard. Quality criteria were not applied to select studies for this review. In each study two investigators collected data independently on indication, CT technique and outcome, using sensitivity, specificity, negative predictive value, positive predictive value and accuracy. Data were used to calculate sensitivity, specificity or positive and negative predictive values if possible, with the help of the available information [3,9,10,12]. Studies were excluded when essential data were missing, when children were included in the study or when different CT modalities were combined and the exact data could not be extracted. We selected the groups by use of the different contrast agents or combinations and one group without contrast. When studies included dual or triple contrast CT scanning and iv contrast was one of the agents, iv contrast was considered to be most important. We included those studies in the iv group. When both enhanced and unenhanced CT techniques were used in a study, data on those different patient groups were included in the relevant category. We extracted the numbers of true positive, false negative, true negative and false positive test results from each study and calculated sensitivity and specificity. In order to pool the results of studies using the same CT method, we used a method for bivariate meta-analysis, as described in detail in Reitsema JB et al [12] and recommended as a standard

of analysis [13]. This method simultaneously estimates the pooled sensitivity and specificity, taking the correlation between these two into account, as well as heterogeneity between studies. The same method was used to test whether there was a difference between CT with contrast compared to CT without contrast. The resulting estimates, together with their 95% confidence regions were plotted in an Receiver Operating Characteristics (ROC) diagram. We also used pooled data to calculate negative and positive predictive values. P-values smaller than 0.05 were considered significant.

RESULTS

Eighteen studies were included in this review. Seventeen were prospective and one study used retrospectively collected results (table 1). Eight studies including a total of 1089 patients, evaluated results of CT scanning without contrast for the diagnosis of acute appendicitis [7,9,10,14,15,16,17,18]. Six studies including a total of 474 patients evaluated results of CT scanning with enteral contrast enhancement: 4 studies used rectal contrast [3,18,21,22], 2 studies used oral contrast [6,23]. Seven studies including 658 patients evaluated results of CT scanning with iv contrast enhancement: 2 studies used iv contrast only [19,20], four studies used combinations of contrast enhancement; two used iv and rectal contrasts, one used triple contrast and one used oral and iv contrast [18,24,25,26]. Figure 1 shows the correla-

Table 1

First author	year of publication	Journal	number of patients analyzed	contrast iv	contrast rectaal	non contrast
rao	1998	N Eng J Med	100		100	
funaki	1998	AJR	100		100	
in 't hof	2004	Br J Surg	103			103
lane	1997	AJR	109			109
cakirer	2002	Emerg Rad	130			130
poortman	2003	AJR	199			199
pickuth	2001	Hepatogastroenterology	120			120
lane	1999	Radiology	300			300
gamanagatti	2007	Sing Med J	58			58
herschko	2007	Dis Colon Rectum	232	84	78	70
johansson	2008	Acta Rad	68	68		
mun	2006	Emerg Rad	173	173		
mittal	2004	Arch Surg	91	52	39	
walker	2000	Am J Surg	57		57	
wijetunga	2001	Rad	100		100	
ceydeli	2006	Curr Surg	75	75		
naffaa	2005	Clin Imaging	75	75		
gaitini	2008	AJR	131	131		

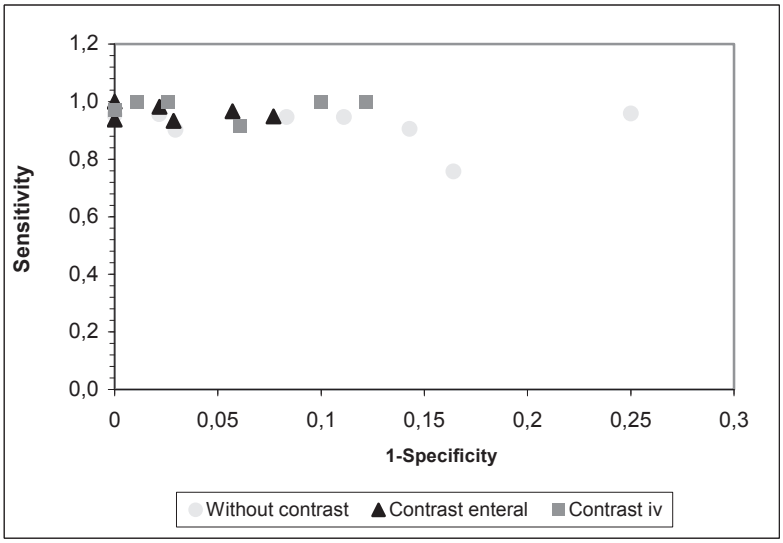

Figure 1

tion and the heterogeneity between the contrast and non-contrast groups of the pooled data after bivariate meta-analysis of both. Figure 2 shows an ROC diagram. Sensitivity was 0.97 (95%CI:0.93-0.99), 0.96 (0.91-0.98) and 0.92 (0.87-0.95) in the iv, rectal contrast and non-contrast group respectively(p=0.04 between iv versus non-contrast, p=0.19 between enteral and non-contrast and p=0.49 between iv versus enteral contrast). Specificity was 0.92 (0.85-0.96),

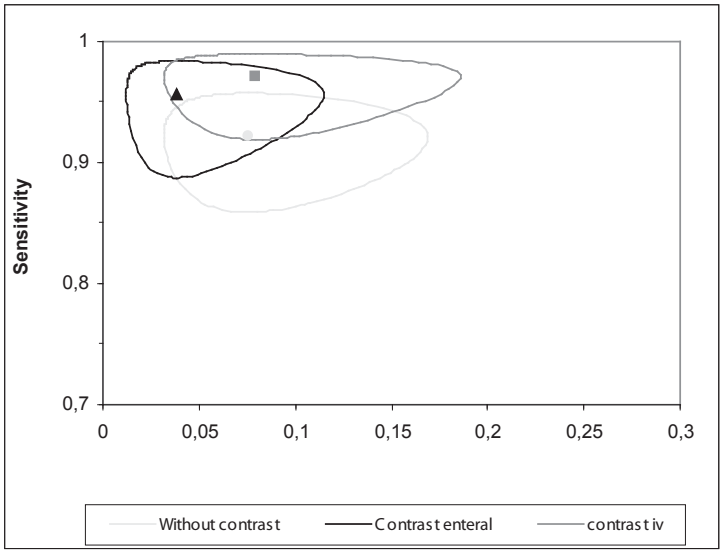

Figure 2

0.96 (0.91-0.98) and 0.92(0.86-0.96) in the iv, rectal and non-contrast group respectively. No significant differences were seen between the different groups. The negative predictive value was 95%, 95% and 87% in the iv, rectal and non-contrast group respectively ($p<0.1$ in as well the iv group versus non-contrast as in the enteral group versus non-contrast). The positive predictive value was comparable: 94%, 95% and 94% in the iv, enteral and non-contrast group respectively. Morbidity and mortality were not reported with either technique.

DISCUSSION

Acute appendicitis is common and around 700,000 times a year an appendectomy is performed in the European Union alone [25]. However, still 7.6% to 42% of operations are unnecessary because the appendix appears normal at exploration [1,2]. This large number of negative appendectomies shows the challenge to the clinician in this patient group. CT has been proven to be the best non-invasive tool to decrease the number of negative explorations [3,7,27,28]. Several CT techniques have been evaluated to diagnose patients with suspected acute appendicitis. CT scanning without contrast enhancement appears the most attractive technique in this patient group. It offers excellent accuracy in selected studies, implies no allergic reactions and is associated with less exposure to radiation, is quick and less costly then CT with contrast enhancement [7,16]. However, in daily practice, the majority of radiologists prefer contrast enhanced techniques in this patient group because of assumed better evaluation of the appendix. This uncertainty created the arguments to perform a meta-analysis of literature on this topic. In this meta-analysis we show that iv contrast enhancement offers better results in patients with suspected acute appendicitis, as sensitivity was significantly higher with use of iv contrast than with use of enteral or without contrast enhancement. Oral administration appears less preferable anyhow because of the frequently encountered disturbed motility in this patient group. In our opinion, iv contrast administration is also the preferred technique because it is quick and implies less discomfort to the patient than rectal or oral contrast. It is however more expensive and high osmolality iodinated contrast media have the potential of evoking allergic reactions [31,31,31]. With adequate steroid premedication, life threatening anaphylactic reactions are rare, even in high risk patients and in our opinion this should not hamper iv enhancement in this patient group [32].

Our analysis has several limitations. Firstly heterogeneity of contrast enhancement techniques existed in the selected trials with iv contrast. Because of this heterogeneity the results are possibly influenced.

Secondly, many studies included children and adolescents as well as adult patients and no differences in diagnostic strategy were made between those groups. In our opinion, particularly in children ultrasonography is the preferred diagnostic tool because of the more compulsory

contraindications to radiation exposure in that group. For that reason we have focused on adult patients in this study.

The third problem was the great diversity in monitoring patients after a negative CT scan. Many studies were flawed because they relied on clinical observation to verify the final diagnosis in patients. In only one trial the value of the CT scan was evaluated prospectively by comparing CT findings with findings at laparoscopic inspection of the abdominal cavity in all patients [7].

Although contrast enhancement in patients with suspected acute appendicitis has better sensitivity, differences in accuracy between enhanced and unenhanced CT techniques are however small as compared to the interobserver variability between experienced and less experienced radiologists for this specific patient group. In a recent study, acute appendicitis was diagnosed on unenhanced multislice CT scans in 69%, 74% and 80% by radiologists with growing experience, while at surgery 83% of patients were actually diagnosed with acute appendicitis [8]. This interobserver variability appears to have greater impact than specific CT protocol on the diagnostic accuracy in patients with suspected acute appendicitis.

Despite these flaws, information provided in the studies included in this meta-analysis shows clearly that iv contrast enhanced CT scanning offers significantly better results than CT scanning without contrast in patients suspected of acute appendicitis. Until different protocols have been studied in randomized controlled trials with enough power to determine the optimal contrast protocol, we advocate the use of iv contrast enhanced CT scanning in every adult patient with suspected acute appendicitis.

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Chapter 5

Laparoscopic appendectomy. A prospective evaluation of in hospital costs associated with open and laparoscopic appendectomy

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Submitted

ABSTRACT

Aim

To compare total hospital costs associated with laparoscopic and open appendectomy

Design

Prospective cohort study

Methods

Inclusion of patients with suspected acute appendicitis in two hospitals. At Medical Center Rijnmond-Zuid (MCRZ, location Clara) patients received laparoscopic appendectomy as standard care. Vlietland Hospital (location Schiedam) managed appendicitis in a conventional open manner. Time application of medical staff, equipment and materials used during operation, in hospital stay and during outpatient clinic visits were recorded prospectively. Total hospital costs were derived and compared. Societal costs were also compared by collecting data from the Central Office for Statistics (CBS).

Results

Thirty-eight patients were included in the laparoscopic group. The open group consisted of 37 patients. Total hospital costs per laparoscopic appendectomy were 2132 Euros of which 1004 Euros were spent on the operative procedure itself. For open appendectomy total hospital costs added up to 1722 Euros of which 566 Euros were incurred by the procedure. Duration of hospital admission was comparable for both groups. A cost reduction of 344 Euros per patient by a 3 days earlier return to work was found.

Conclusions

Hospital costs for laparoscopic appendectomy remain higher than for open appendectomy because of increased peroperative costs. Because of a quicker return to work, costs on a societal level can actually be similar.

INTRODUCTION

Appendectomy for acute appendicitis is one of the most common surgical interventions: six percent of all surgical procedures.[1] Since the introduction of laparoscopic appendectomy several randomised trials and meta-analyses have been published. The laparoscopic technique is safe and has in addition diagnostic advantages. Other clear benefits in comparison with the open technique like, less pain and a quicker recovery have been extensively reported in literature.[2] Beside clinical effects and the learning curve of a new technique, financial considerations also play an important role in the implementation of the laparoscopic technique. Not only are health insurance companies important players in the healthcare sector, but also there is an increasing awareness that the scarce resources should be spent optimally also in the health care sector[3]. An integral cost comparison of newer techniques for the same indication are important in the adoption of a new health product. Aim of this study is to calculate and compare the total hospital costs of open and laparoscopic appendectomy. Societal costs will be counted separately as far as possible.

METHODS

In two hospitals within the Rotterdam region consecutive adult patients with suspected acute appendicitis were included in a prospective study following clinical investigation, laboratory tests and in most patients ultrasonography or CT scanning. One hospital (MCRZ location Clara) laparoscopy was standard care if there were no contraindications. In the other hospital (Vlietland Ziekenhuis, location Schiedam) open appendectomy was performed as standard care. Occasionally in this hospital patients received a laparoscopic procedure when this was the preference of the surgeon. Since there are few results published on differences in costs between both treatments a formal power analyses was not executed. A total of around 80 patients were considered to be sufficient. Patients in the laparoscopic group who nevertheless received open appendectomy (for example after conversion) were analysed in the laparoscopic group, in accordance with the intention to treat principle. Patients in the open group who received a laparoscopic intervention were excluded to avoid suspected disadvantages as a longer operating time or expensive instruments to add to overall costs of the open group. The laparoscopic technique commenced with the establishment of pneumoperitoneum in an open fashion. After inspection of the abdominal cavity appendectomy was performed if there was macroscopic suspicion of acute appendicitis through one to up to four trocars. The appendiceal stump was secured using loops or an endoscopic stapler (Endo GIA 30; US Surgical Corp, Norwalk, Connecticut, VS). In accordance to the extent of inflammation an endobag (Endocatch; US Surgical Corp, Norwalk, Connecticut, VS) was used to remove the appendix. In the open group a gridiron incision was made at the level of McBurney and the appendix was

always removed. Every removed appendix was sent for pathological examination. The applied definition of acute appendicitis was the observation of granulocytes throughout all layers of the appendix.

Costs were assessed in accordance with the Netherlands guidelines for costing process in health care and for pharmacological-economic studies.[4,5] The in hospital costs consisted of costs incurred during surgery, cost of hospital admission and costs associated with outpatient clinical visits. Costs were calculated by multiplication of volumes (duration of time, number of admission days etc) and cost-prices per unit (cost-prices of operation materials etc). Volumes were prospectively recorded for devices, (disposable) instruments, materials used, time spent by personnel, operative time and out patient clinic consults. For operative time, total length of stay in the operating theatre was used. Also total hospital stay was recorded. For in hospital stay and out patient clinic visits the actual 2006 prices as recommended by the Dutch Health Insurance Board were used.[4] For calculating the cost-price of materials and devices the actual purchase prices were used. Personnel costs included gross salary, operating disorder supplement and employer's contributions to national insurance. Basic costs of the operating room and instruments were costs for sterilisation, reduction in value and service. Overhead costs, like administration and cleaning were also included in this group using surgery time as extent. All costs were translated into costs per procedure. The combined data provides a complete cost price for open and laparoscopic appendectomy, including surgery, in hospital stay and outpatient clinical follow up. Data were statistically analysed using SPSS(Chicago, Illinois, VS) with a t-test (normal range) or Mann-Whitney-U test (different range). The productivity costs were calculated on the basis of data from the Central Office for Statistics(CBS). Accounted for is also the workforce participation, weighted for age and gender as known from the labour force enquiry conducted by the CBS.

RESULTS

In the open group 37 patients were included (five patients were excluded because of a laparoscopic procedure) versus 38 in the laparoscopic group. Figure 1 shows the groups in a flow chart. There were no differences in demographics or diagnosis (table 1). For the overall physical condition we used the classification of the American Society of Anaesthesiologists. This classification was similar for both groups.[5] In the laparoscopic group one patient had primary open surgery because of technical problems. In two patients conversion was necessary due to an extended appendicular mass and one because the appendix was not found. In four cases there were no signs of acute appendicitis microscopically. In all these cases symptoms disappeared without additional treatment. Also in the open group in four patients a normal appendix was observed. In table 2 the costs of surgery, in hospital stay and outpatient clinical consults are described. Personnel costs in the laparoscopic group were higher due to sig-

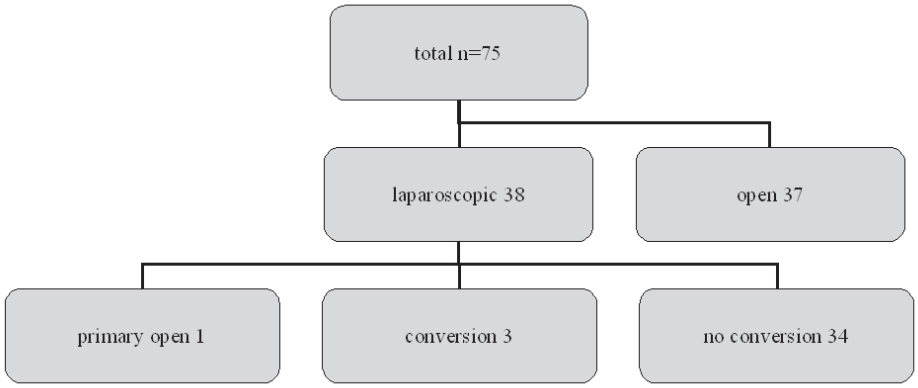

Figure 1 Patient groups

Table 1. Demographic data

	laparoscopy	open
age(mean, years)	69	64
man/female ratio	0.7	0.9
ASA classification (mean)	1.2	1.2
acute appendicitis (%)	89	92

nificant (p=0.04) longer operative times (72minutes SD: 25.1 versus 56 minutes SD: 24.6). No significant difference in hospital stay between the two groups was demonstrated (2.9 days SD: 2.4 versus 2.8 days SD: 1.4). There was no difference in morbidity between the two groups. The mean number of outpatient clinic visits was not significantly different (1.6 SD: 1 in the laparoscopic group versus 1,5 SD: 1 in the open group). The average total hospital costs per laparoscopic appendectomy was 2132 euros and 1722 euros for open appendectomy. In our

Table 2. Comparison of hospital costs in euro.

Kind of costs	procedure	
	laparoscopy	open
admission/nursingcosts	640	618
Operative costs/intervention		
Basic costs	368	229
Anaesthesiologic materials	115	115
overhead costs personnel	376	376
anaesthesiologist	43	34
surgeon	86	68
OR personnel	118	92
Disposable instruments and materials	306	116
Outpatient clinic consults	79	74
total	2132	1722

study group a cost reduction of 344 euro per patient by a 3 days earlier return to work was found (CBS data).

DISCUSSION

It does not come as a surprise that laparoscopic appendectomy leads to increased hospital costs, which are mainly related to the increased use of devices and disposable instruments. Reducing the use of disposable instruments will reduce the costs of laparoscopic appendectomy significantly. If reusable instruments had been used instead of disposable instruments the total costs would have been reduced to 2005 instead of 2132 euro. The application of Endoloops instead of endoscopic staplers will also reduce costs, in our study the endoscopic stapler was used in four occasions. However a recent review about closing the appendiceal stump in laparoscopic appendectomy favours routine use of endoscopic staplers.17 While costs are important, they are clearly not the only important aspect. The health benefits produced by the intervention are the central outcome in the health care sector. In that context, the use of reusable instruments is safe and also cost saving. However, the use of endoloops instead of stapler is cost saving in financial terms, but comes at a price in terms of health outcomes: significant more postoperative ileus and superficial wound infections.[17] The longer operating time is in accordance with the literature.[2,7] Worth mentioning is that the hospital in which laparoscopic appendectomy was performed, is a surgery teaching hospital. As appendectomy is a teaching operation for surgical residents, learning effects had probably negative effects on the operating time. In the open group appendectomy was only performed by qualified surgeons. It can be argued that more experienced surgeons would reduce operating times in the laparoscopic group, however the Cochrane review of Sauerland et al showed a longer operative time in the laparoscopic group of 14 minutes.[2] This is close to the 16 minutes difference found in this study. A shorter in hospital stay for the laparoscopically treated patients was not found in this study. Regarding hospital stay there is a discrepancy with a meta analyse reporting patients after laparoscopic appendectomy having been discharged from the hospital 1,1 day earlier than following open surgery.[2] The groups in our series were possibly to small to detect this difference, although the averages were quite similar as well. In patients after laparoscopic surgery activities of daily life are reported to be resumed four until eight days faster than in patients after open appendectomy.[2] Randomised trials also show a three up to six days earlier return to work.[8,9] Indirect non medical costs induced by sick leave causing a loss in productivity are expected to be lower for the laparoscopic group. From a societal perspective the higher total hospital costs of laparoscopic appendectomy may thus be compensated by lower costs of absence through illness. Two European studies confirm that laparoscopic appendectomy is cost saving with regards to indirect costs.[11,12] Besides short term effects, long term effects have to be taken into account before making an informed choice between laparoscopic or open ap-

pendectomy with regard to economic effects. The occurrence of incisional hernias, adhesions and their consequences is reported to be lower after laparoscopic appendectomy.[13] Reduction of complications in the laparoscopic group is also due to abstain from appendectomy in patients with a macroscopically normal appendix.[14] During open procedures, appendectomy is always performed, with a complication percentage of 6.7%.[15,16] Standard performance of laparoscopic inspection of the abdominal cavity seems valuable in reducing unnecessary appendectomies and associated postoperative complications and costs. Although we focused here on hospital costs, the health benefits nor possible societal advantages of a laparoscopic inspection followed by laparoscopic appendectomy in case of inflammation of the appendix should obviously not be ignored. In such a broader evaluation, the additional health benefits of laparoscopic appendectomy may be obtained at similar costs than open appendectomy or may be considered worth the additional costs.

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Chapter 6

Is less more?
A prospective trial on one trocar appendectomy

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ABSTRACT

One trocar appendectomy is a combination of laparoscopic and open appendectomy. The advantage, along with improved cosmesis, is the possibility to introduce a dissection instrument through the optical trocar without an additional incision. In this prospective study the sense of one trocar appendectomy is evaluated in daily practise for a cohort of consecutive patients with suspected acute appendicitis. Twenty-two patients were enrolled. One-trocar appendectomy was successful in 13 patients. In 8 patients one extra 2, 5 or 10millimetre trocar was necessary. In one patient a third trocar was necessary. Conversion to an open appendectomy through a grid iron incision was not necessary. The pathologist confirmed the diagnosis of acute appendicitis in all patients. The average operation time was 53 minutes. Complications included one wound abscess and one wound haematoma. In conclusion one trocar appendectomy is a good and safe technique in patients with the suspicion of acute appendicitis, provided that the operative team must be experienced in laparoscopic surgery and the constitution of the patient is suitable for this technique.

INTRODUCTION

Appendectomy is performed annually in almost 700,000 patients in the European Community rendering it the most frequent acute surgical procedure(1). Despite the frequency of acute appendicitis the optimal surgical procedure for acute appendicitis is still under debate. It has been shown in a variety of randomized trails and meta-analyses that laparoscopic appendectomy is superior to open appendectomy with regard to postoperative pain, further use of analgesia and return to normal activities(2,3). The first laparoscopic appendectomy was described by de Kok in 1977 and developed by Semm(4,5). The laparoscopic technique combines minimal surgical trauma with the possibility to explore the entire abdominal cavity. It is an excellent diagnostic tool in view of the high percentages of negative appendectomies in open appendectomy(6,7). Downsizing laparoscopic instruments has been shown to be advantageous in laparoscopic cholecystectomy, and antireflux surgery(8,9). From these observations one could argue that this same holds true for laparoscopic appendectomy. Successful laparoscopic appendectomy using one 12mm trocar without additional trocars has been described in small groups of patients(10,11,12). In this study our first experience with one-trocar appendectomy is described, focusing on indications and complications.

METHODOLOGY

Between January 2003 and January 2005, 22 patients with suspected acute appendicitis who presented to the emergency department of the Medical Centre Rijnmond-Zuid underwent one trocar appendectomy. Inclusion criteria were: the clinical suspicion of acute appendicitis established by senior surgeons with standard use of anamnesis, physical examination, blood -and urine samples and on demand ultrasonography or computed tomography. All patients were scheduled for emergency laparoscopy. The surgeon on call should master the technique, on our department two surgeons. Exclusion criteria were contra-indication to laparoscopy, contra-indication to general anesthesia or pneumoperitoneum, pregnancy and generalized sepsis. Data collection was done prospectively.

Pre-operative care and antibiotics

Surgery was performed under general anesthesia. All patients received 1gr cefotaxime and 500 mg metronidazole intravenously at the time of induction. Patients did not receive a urinary catheter routinely.

One trocar appendectomy

The left arm of the patient was positioned along the body with the patient in supine position. The right side of the patient was tilted at 30^{o}. The surgeon standed on the left side of the pa-

tient during the procedure. Establishment of pneumoperitoneum was performed in an open fashion, infraumbilically, in all patients. A special 10 mm O° telescope was introduced. This instrument has been designed originally for endobronchial manipulations (Storz, Germany). The telescope is a combination of an endoscope and an operative channel. The scope is delivered with extra long, 450mm, instruments. After insufflating the peritoneal cavity with CO2 at a 14mm Hg pressure, the patient was placed in a Trendelenburg's position. After inspection a grasper was used to retract small bowel loops and greater omentum and a dissection instrument was used for further inspection and dissection. Once the appendix was completely free, the mesoappendix was grasped at the top. Subsequently pneumoperitoneum was released, and appendectomy was performed outside the abdomen by pulling the appendix through the infraumbilical incision together with the trocar. To allow good exposure, the abdominal wall was retracted by narrow-shaped retractors. The meso-appendix was ligated step by step, the appendix transected after ligation. After completion of appendectomy the Hasson trocar was re-inserted to allow inspection of the length of the appendiceal stump and for aspiration and irrigation of the peritoneal cavity in case of peritonitis.

Post-operative care
Postoperative diet of patients was on demand. For patients with perforated appendicitis intravenous antibiotics were administrated for five days. All patients were followed up postoperative by six weeks after surgery at the outpatient clinic.

RESULTS

A total of 22 patients were enrolled in this study: thirteen women and nine men. The mean age was 18; range 6-37 years. One trocar appendectomy was successful in 13 patients. In 8 patients (45 percent) one extra 2, 5 or 10millimeter trocar suprapubic was necessary. In one patient a third trocar was necessary. In 22 percent of these patients the appendix was located posterior to the cecum. Seven patients (32 percent) had to much subcutaneous fat to retract the appendix infraumbilically. In these a second suprapubic trocar was necessary to remove the appendix with a stapler or endoloops and the use of an endobag. Conversion to the open technique was not necessary. Average operative time was 53 minutes. The diagnosis of acute appendicitis was approved in all patients by pathological examination, showing neutrophilic leucocytes through all layers of the appendix. The average hospital stay was two days. Complications included one wound abscess and one wound hematoma, both with regard to the infraumbilical wound. No reintervention was necessary.

DISCUSSION

In this study we show that one trocar appendectomy, if possible, in patients with suspected acute appendicitis is a safe technique, provided that the operative team is experienced in laparoscopic surgery and the constitution of the patient is suitable for this technique. As results are promising, we feel that endoscopic surgeons should become aware of this technique and should be trained. Especially because new instruments are developed with two working channels through a telescope combined with the use of flexible instruments which might give this technique an extra impulse. Also the development of notes gives an extra dimension to this technique and even combination of both are in the future maybe wishful. Some studies show an advantage in using less or smaller instruments (<3mm) with respect to a decreased use of postoperative analgesia, which may shorten convalescence and improve cosmetic results especially in laparoscopic cholecystectomy and laparoscopic antireflux surgery(8,9). In laparoscopic surgery 'less trauma' seems to give more benefits to the patients. One trocar appendectomy can be one of the techniques to support this hypothesis. High percentages of negative appendectomies are still described, specially in series of open appendectomies. Different diagnostic tools have been proposed to decrease this percentage. Unenhanced helical CT can diagnose appendicitis accurately, however to reach this level of diagnostic yield, expert interpretation is necessary, which is not always possible in daily practice(13). Diagnostic laparoscopy enables the surgeon to diagnose acute appendicitis accurately(14). The one trocar appendectomy-telescope with a working channel is ideal for this purpose because it has the possibility to visualize the appendix without introduction of an extra trocar.

In our opinion in children and slim patients with acute appendicitis one trocar appendectomy can be fulfilled even by mobilization of the coecum. If during operation the one trocar technique is not possible due to the position of the appendix, the ideal trocar position can be estimated and extra trocars can easily by introduced. In our opinion is one trocar appendectomy not possible in patient with a body mass index of more than 23, although we have not enough patients in our population to confirm this with a graphic. The operative time of 53 minutes in this series is comparable with the reported average time of conventional laparoscopic appendectomy. This is significant longer than the operative time of open appendectomy(15). If the appendix is not located posterior (about 50%) one trocar appendectomy is a usable technique. When imaging techniques are improving fast and will be implemented more often it is foreseen that in the future the exact position of the appendix can be predicted preoperatively. Under those circumstances a tailor-made indication of technique, like one trocar appendectomy, will be realistic. In conclusion one-trocar appendectomy is a good and safe technique in children and slender patients with the suspicion of acute appendicitis provided the operative team is experienced in laparoscopic surgery.

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Chapter 7

Laparoscopic appendectomy

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In Minimally Invasive Surgery; Mark A Talamini (editor), BC Decker Inc 2006;233-41

INTRODUCTION

Appendectomy is performed annually in almost 700,000 patients in the European Community rendering it the most common acute surgical procedure. Mortality following appendectomy is 0-0.24% and is related to the severity of peritonitis present at the initial operation. Morbidity following appendectomy varies between 5.2-11.3% and is determined by the presence of a perforation of the appendix and the degree of peritonitis at the time of surgery. The first description of an appendectomy dated from 1736 Cladius Amyand operated a boy with an appendix in his scrotum. He removed the appendix and repaired the hernia and the boy recovered. In 1839, Addison and Bright described in detail the symptoms and signs of appendicitis in their book: Elements of the Practice of Medicine, but did not describe a good treatment. The first successful elective appendectomy was performed and described in 1883 by Abraham Groves [1]. However, almost 20 more years elapsed before appendectomy was considered common sense in patients with right lower quadrant pain. Treatment of patients with perforating appendicitis improved considerably after the introduction of penicillin in 1943.

In 1995, a clinical trial that randomized patients with acute appendicitis to either initial treatment with antibiotics or emergency appendectomy revealed that 40% (8 of 20) of the antibiotics group required appendectomy. In 1 patient, peritonitis developed after 12 hours, necessitating appendectomy. The other 7 patients were readmitted within one year because of recurrent appendicitis [2]. The controversy over timing of surgery for appendicitis has since disappeared, and emergency appendectomy is advocated in patients with acute appendicitis.

Emergency surgery for suspected appendicitis is, however, hampered by unnecessary appendectomies (20 %) and perforating appendicitis (20 – 25 %) [3]. The surgical technique of open appendectomy had undergone few changes since its first description by McBurney in 1884, until 1997, when the Dutch surgeon de Kok reported successful laparoscopic appendectomy in a patient with chronic appendicitis [4]. The gridiron incision in the right lower quadrant of the abdomen was propagated by McBurney and accepted by the majority of surgeons for more than one century as the standard [1]. This is surprising because the gridiron incision allows limited exposure of the abdomen and poor access to abdominal pathology other than appendicitis. Furthermore, surgical tradition dictates removal of the appendix, irrespective of the presence of inflammation, to prevent later confusion about the presence of the appendix. The ability to remove the diseased appendix laparoscopically and the employment of novel imaging tools such as spiral computed tomography (CT) in patients with acute appendicitis have caused a revolution in the approach to acute appendicitis that is still in an early phase and still under debate.

MINIMALLY INVASIVE VERSUS OPEN APPENDECTOMY

A large number of randomized clinical trials have been performed comparing laparoscopic and open appendectomy. Meta-analyses of these trials have shown clear advantages of laparoscopic appendectomy (table 1). Laparoscopic removal of the inflamed appendix induced less wound infections, caused less postoperative pain, reduced hospital stay and allowed earlier recovery at the expense of longer operating time and higher operative costs. However, the sum of in-hospital and out-of- hospital costs was lower. A trend was recognized towards increased intra-abdominal abscess formation after laparoscopic appendectomy, although Kazemier and colleagues could not confirm this [5, 6]. Formation of adhesions owing to appendectomy has been rarely studied. However, in a trial comparing laparoscopic appendectomy and open appendectomy, de Wilde showed a reduction of 70% of intra-abdominal adhesions on follow-up laparoscopy after 3 months [7]. The long-term advantage from adhesiolysis has never been studied before. Another advantage of laparoscopy is the ability to inspect the whole abdominal cavity and hence recognize adnexitis, sigmoiditis, cholecystitis, colitis and gastric perforation in patients with a normal appendix. In spite of these results, and although appendectomy accounts for over 6% of all surgical procedures in daily practice, widespread employment of laparoscopic appendectomy remains limited. Concern about establishing a pneumoperitoneum in patients with peritonitis, insufficient laparoscopic experience, higher operative costs and longer operating time appear causative factors.

Tabel 1. Results of Meta-analysis of Continuous Outcomes and Heterogeneity of Outcomes

Outcomes	LA*	OA*	Pooled Mean Differences (95% CI)	Effect p value	homogeneity p Value
Operative time(min)	63	50	-15(-12- -18)	<10-5	<10-3
VAS pain score day1(0-110) 35 51	13(10-17)	<10-5	.005		
VAS pain score day2(0-100) 11	25	11(17-15)	<10-5	.111	
Parenteral pain medication† 1.8 2.7	0.92(0.69-1.16)	<10-5	<10-4		
Oral pain medication†	2.4 3.5	0.42(-0.08-0.92)	.26	.003	
Days to liquid diet	1.2 1.4	0.15(-0.02-0.31)	.22	.59	
Days to solid diet	1.9 2.1	0.27(0.12-0.42)	.006	.03	
Days in hospital	3.2 3.9	0.68(0.41-0.98)	<10-5	.01	
Days till normal activity 14.7 19.3	4.8(3.7-5.9)	<10-5	<10-5		

CI = confidence interval; VAS = visual analogue scale.

* Mean values of outcomes in laparoscopic (LA) and open appendectomy (OA) group

† Total number of doses

PATIENT SELECTION AND EVALUATION

Pain in the right lower quadrant without a mass

In an emergency setting, the anamnesis and physical examination are the cornerstones of establish a correct diagnosis in patients presenting with acute abdominal pain localized in the right lower quadrant. A report of Anderson and colleagues on the diagnostic value of medical history, clinical presentation, and inflammatory parameters in a group of patients with suspected appendicitis showed that none of the single variables had sufficient discriminating power to be used as a true diagnostic test [8]. Another report showed that a normal C-reactive protein (CRP) level correlated strongly with a normal appendix in patients with suspected appendicitis [9]. A study of Bohner showed that the presence of 3 out of 5 clinical parameters (rebound tenderness, tenderness in the right lower quadrant, onset of pain in the right lower quadrant, rigidity and guarding) had a positive predictive value of 85% [10]. To improve accuracy, computer-aided algorithms have been developed. A randomized study by Ohmann and colleagues that compared a group of patients undergoing standard diagnostic work-up (with no additional diagnostic support) with a group of patients undergoing additional diagnostic support with a score found no differences in the rate of perforated and normal appendices or in postoperative complications [11]. However, the diagnostic accuracy of the final examiner decreased using the diagnostic score. They concluded that the score could not be recommended as a standard tool for diagnostic use because these algorithms are mostly based on subjective observations and require new and expensive equipment. During the past decades, several imaging techniques have been developed that have improved the diagnostic accuracy of acute appendicitis in patients. The value of preoperative ultrasonography has been shown in numerous studies, some with excellent outcomes. However, the experience of the ultrasonographer is of paramount importance.

Obesity and guarding diminish the accuracy of ultrasonography to assess thickening of the appendix; because the distance between ultrasound probe and the appendix should be short to allow accurate imaging, it is not reproducible [12]. However, Wise and colleagues showed that ultrasonography has a high inter- and intraobserver variability [13]. Preoperative CT imaging with contrast enhancement has also been shown to be highly accurate in confirming or ruling out appendicitis in all patients suspected of acute appendicitis. A sensitivity rate of 100% and specificity of 97% have been reported [14]. CT imaging appears to be superior to ultrasonography in diagnosing appendicitis [15, 16]. The CT scan without contrast is (1) less expensive and less time consuming; (2) gives less discomfort to the patient because oral, rectal of intravenous contrast is not used; and (3) only takes a few minutes, and is associated with fewer allergic complications because contrast is not given. In a recent study in our hospital, we showed a sensitivity rate of 95% and a specificity rate of 95 and 100% for the diagnosis acute appendicitis with use of a CT scan without contrast [17]. In this study, all patients suspected of acute appendicitis underwent unenhanced helical CT of the abdomen. Subsequently, all pa-

tients underwent laparoscopic inspection of the abdominal cavity by a surgeon blinded to the CT diagnosis. Patients underwent appropriate surgical therapy accordingly. In our opinion, for patients who are suspected of acute appendicitis, especially in women, the CT scan can rule out or confirm the diagnosis.

Pain in the right lower quadrant with a mass

An appendiceal mass is likely in patients presenting with a history of longer duration of right lower quadrant pain. This can be a large phlegmon or an abscess, a malignancy is possible as well. It is essential to differentiate between these entities because they require different therapy. Imaging techniques such as ultrasonography and CT scan can provide information to differentiate these entities. In our opinion, the CT scan is superior, especially because the images are reproducible. An appendiceal abscess should be drained, preferentially percutanously, under CT or ultrasonographic guidance. A phlegmon should be treated nonsurgically because complication rates of early surgery range from 15 to 50% and conservative treatment has shown to be safe [18]. Conservative treatment involves bed rest and pain relief. Following successful conservative treatment interval appendectomy is not necessary. Only 6.6 to 8.5% will develop recurrent appendicitis [19]. Colonoscopy or barium enema should always be performed to rule out possible noninfectious causes of appendiceal mass, such as adenocarcinoma of the right colon or appendix, carcinoid of the appendix, or colitis. The incidence of adenocarcinoma of the right colon can be as high as 8% in patients with an appendiceal mass.

LAPAROSCOPIC APPENDECTOMY

Laparoscopic appendectomy requires the presence of a surgical team that has received proficient training in basic laparoscopic skills and the availability of high-quality videoscopic imaging. If these criteria cannot be met, then open appendectomy is preferable. The patient and family should be informed preoperatively that the incisions are made in the left lower quadrant to remove the appendix laparoscopically, to avoid confusion in patients who expect an incision in the right lower quadrant. Placement of the intravenous line in the right arm is preferable to allow positioning of the left arm along the body of the patient during laparoscopic appendectomy (figure 1). Both the surgeon and camera driver stand on the left side of the patient during the procedure. Administration of antibiotics at induction of anesthesia is mandatory to reduce intra-abdominal abscesses and wound infection. Andersson and colleagues reviewed 44 studies comparing antibiotic regime to placebo in patients undergoing appendectomy for suspected appendicitis [20]. Overall the use of antibiotics was found to be superior to placebo with regard to wound infection and intra-abdominal abscess, regardless of the degree of inflammation of the appendix. Although a similar outcome is expected

for laparoscopic appendectomy, no evidence exists to support the contention that patients undergoing laparoscopic appendectomy will also benefit from antibiotic prophylaxis. Risks of more than 10% of conversion justify prophylactic antibiotics for laparoscopic appendectomy. Insertion of a urinary catheter is not necessary when the patient has emptied the bladder prior to surgery. The patient is placed in supine position, with the right side tilted at 300 to facilitate mobilization of the cecum (figure 2). Either a cushion or a beanbag can be used to position the patient in right tilt. Establishment of the pneumoperitoneum is done in an open fashion in all patients. Visceral and vascular lesions are more common after closed establishment of a pneumperitoneum [21]. A semicircular incision is made in the lower or upper fold of the umbilicus, based on the anatomy of the umbilicus. Kocher clamps are placed on the vertical raphe of the fascia, and the fascia and peritoneum are opened under direct vision. Stay sutures are placed to secure the Hasson's cannula. These sutures are also employed to close the fascia at the end of the procedure. In patients with a midline scar owing to previous abdominal surgery, the first trocar should be inserted in the right midclavicular line at the level of the umbilicus to allow inspection and lysis of adhesions in the midline. The pressure of gas insufflation is determined according to the individual patient. The key is to work at the lowest pressure possible to limit adverse hemodynamic effects. After insufflating the peritoneal cavity, the patient is placed in Trendelenburg's position to displace the small bowels

Figure 1

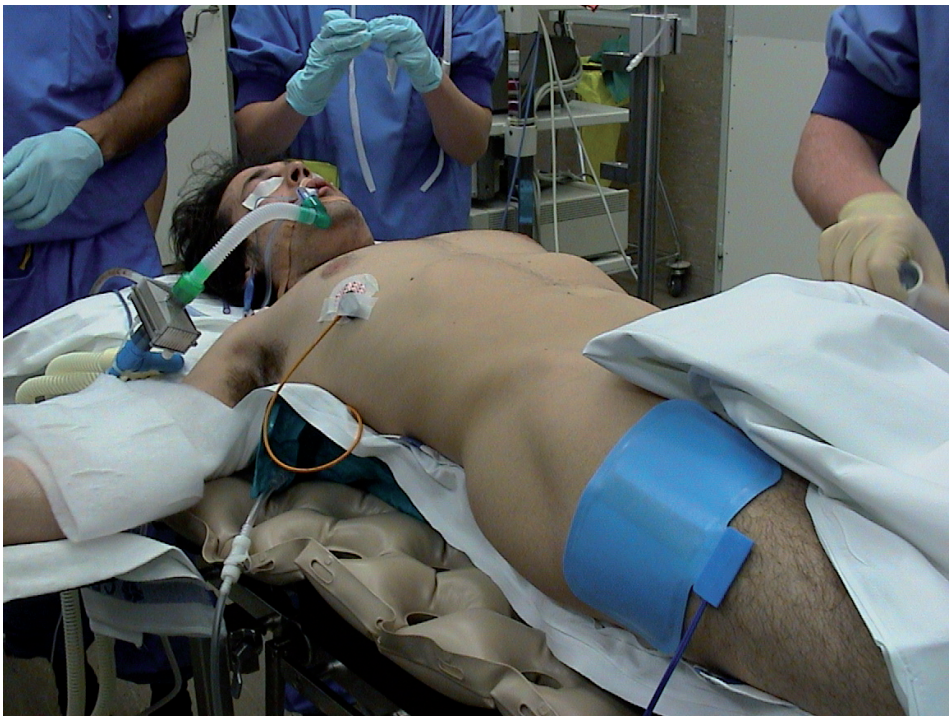

Figure 2

from the small pelvis. A 10 mm 0° laparoscope is introduced to inspect the entire abdominal cavity. In most patients, placement of a second trocar is mandatory to allow introduction of an atraumatic grasper to retract small bowel loops and the omentum. A 5 mm trocar is placed just cranially to the pubic bone in the midline (figure 3). The peritoneum tends to be very lax in the lower abdomen, rendering introduction of the trocar difficult (figure 4). Rotating the trocar during introduction and patience will allow safe introduction of the trocar. Identification of the appendix is the first step. When the appendix is located posteriorly to the cecum, the cecum should be mobilized by cutting down at the white line of Toldt. A third trocar is usually necessary to insert a second instrument to mobilize the cecum. The third trocar is placed just medially to the left anterior superior iliac spine (figure 3). Care should be taken to avoid lacerating the epigastric vessels. Laparoscopic inspection of the appendix involves assessment of color, thickness, mobility, perforation, and fixation. Color during videoscopic surgery is dependent on light intensity, transparency of the laparoscope, and quality of the camera and screen. A defective imaging chain can obscure or exaggerate redness of the appendix. An inflamed appendix is rigid, whereas an unaffected appendix is floppy.

Perforation of the appendix is obvious in most cases. Fixation of the appendix is indicative of appendicitis when previous generalized peritonitis has not occurred. When the appendix appears normal, inspection should continue and should involve the gallbladder, stomach, duodenum, pancreatic body exposed through the lesser omentum, sigmoid colon, distal 100 cm

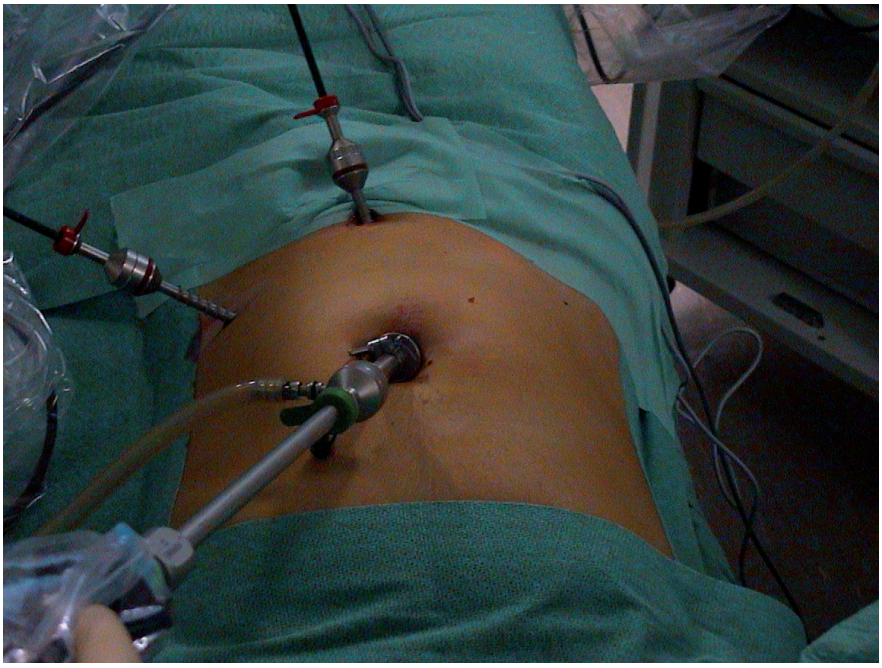

Figure 3

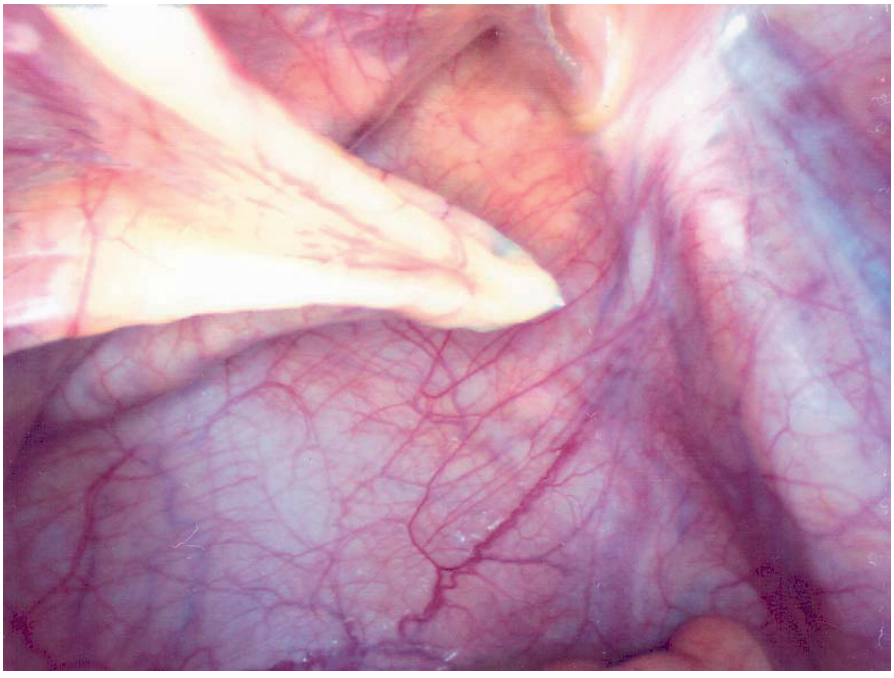

Figure 4

of ileum, ovaries, fallopian tubes, and uterus. There is no evidence in the literature to support to removal of a normal appendix in patients with acute lower quadrant pain. The removal of a normal appendix renders considerable complications (up to 6%) and costs [22]. When a clearly inflamed appendix is present, dissection is determined by the position of the appendix. In some cases, an antegrade dissection, from base to tip, of the appendix is preferable. Transecting the base of the appendix in an early phase facilitates this. A stapling device with a blue cartridge is the instrument of choice for transect the appendix (figure 5). However, in the majority of cases, retrograde dissection is possible. After the appendix has been loosened from the surrounding tissues, the mesoappendix is skeletized. To allow dissection of the mesoappendix, the appendix has to be retracted. The preferred method is retraction of the mesoappendix in order to avoid perforation of the appendix owing to grasping (figure 6). When the mesoappendix cannot be grasped effectively, a pretied loop placed at the tip of the appendix can serve as a retraction handle. The mesoappendix harbors the appendicular artery that runs at its base. Depending on the caliber of this artery, occlusion can be accomplished by diathermy, clips, or ultrasonics (figure 7). When diathermy is used, care should be taken to avoid contact between the uninsulated tip of the dissection instrument and the terminal ileum to prevent late perforation of the ileum. The entire appendix should be freed. This is confirmed by visualizing the base of the appendix and the ability to move the appendix around freely. Reports exist on partial appendectomy during laparoscopic removal. Once the entire appendix has

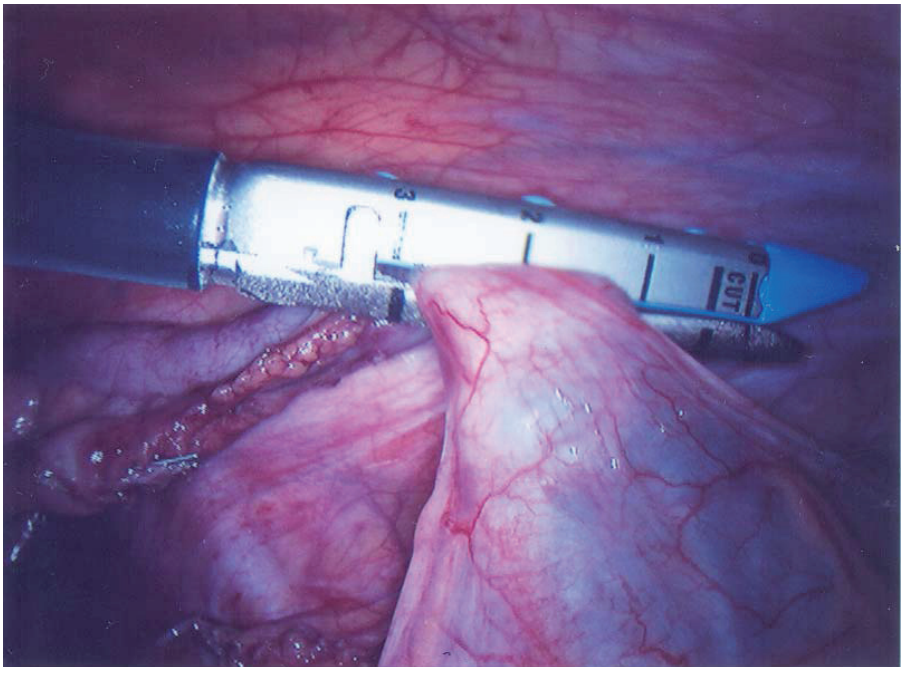

Figure 5

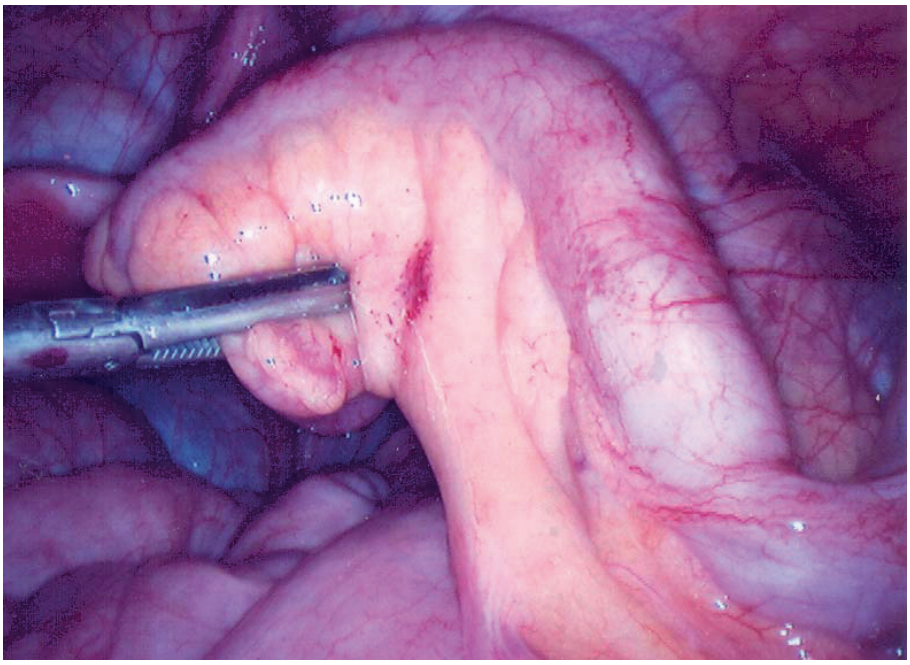

Figure 6

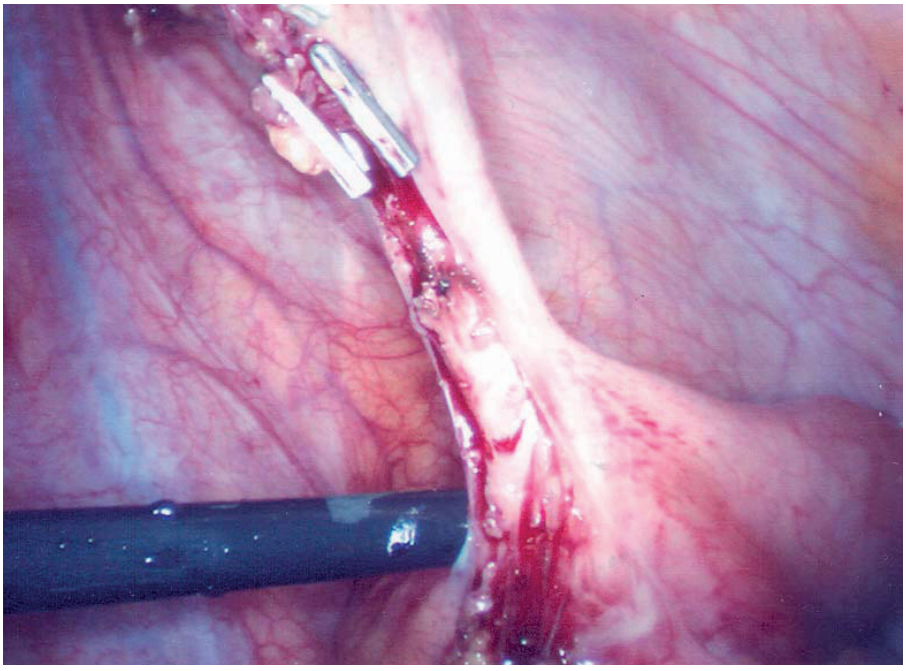

Figure 7

been freed (figure 8), occlusion of the appendix can be accomplished by one or two prettied loops at the base of the appendix and one more distal at the appendix (figure 9). Application of diathermy during transection of the appendix, which has been proposed to cauterize bacteria in the appendiceal lumen, should be avoided to prevent tearing the loop. The distal loop should not be cut because it can be used to extract the appendix. Alternatively, the appendix can be occluded and transected by a 30 mm stapling device with a blue cartridge (figure 5). When a stapling device is employed, care should be taken to not include clips in the staple line because this will cause misfiring. In the case of bleeding at the staple line, compression with a gauze usually suffices. If bleeding persists, then either a clip or a suture can be placed. Diathermy should be avoided to prevent necrosis at the staple line. Use of a stapling device requires insertion of a 12 mm trocar that is placed preferentially suprapubically for better cosmesis. Employment of a stapling device is mandatory when a perforation at the base of the appendix is present. In such cases, the stapler is placed over the cecum to exclude the perforation. The appendix is extracted through the largest trocar. If one 10 mm trocar and two 5 mm trocars have been inserted, then a 5 mm laparoscope can be inserted through one of the 5 mm trocars to allow removal of the appendix through the 10 mm trocar. When easy passage of the appendix through the trocar is unlikely, the appendix is placed in a plastic bag prior to removal to prevent spillage (figure 10). Drains are not left behind. Lavage is performed routinely if blood or purulent material is left after appendectomy. All trocars are extracted under direct vision to identify bleeding at the port site. In case of port site bleeding, coagulation

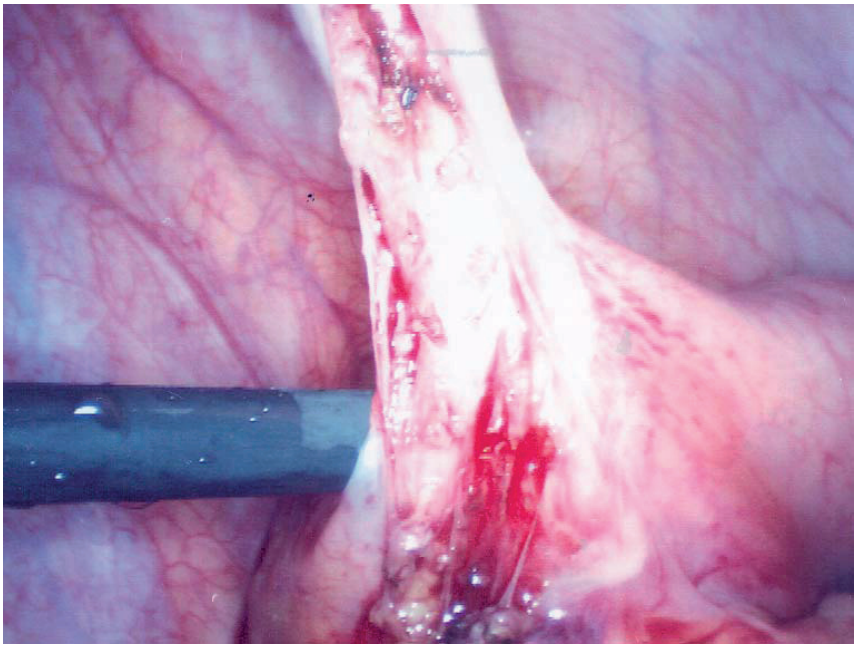

Figure 8

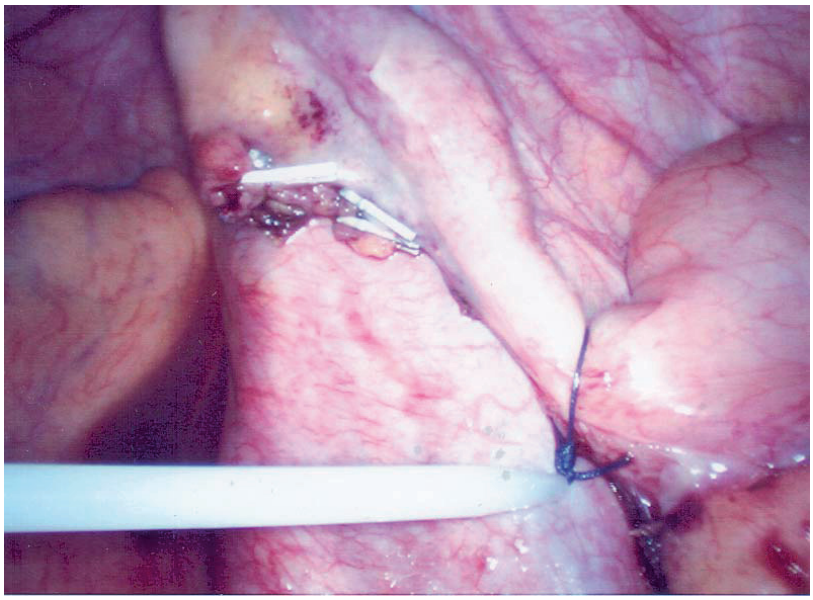

Figure 9

by a laparoscopic instrument inserted via another port is attempted first. If unsuccessful, then closure of the port site with suture passers that are inserted under laparoscopic guidance is the next step. Closure of the wound is possible with absorbable or nonabsorbable sutures.

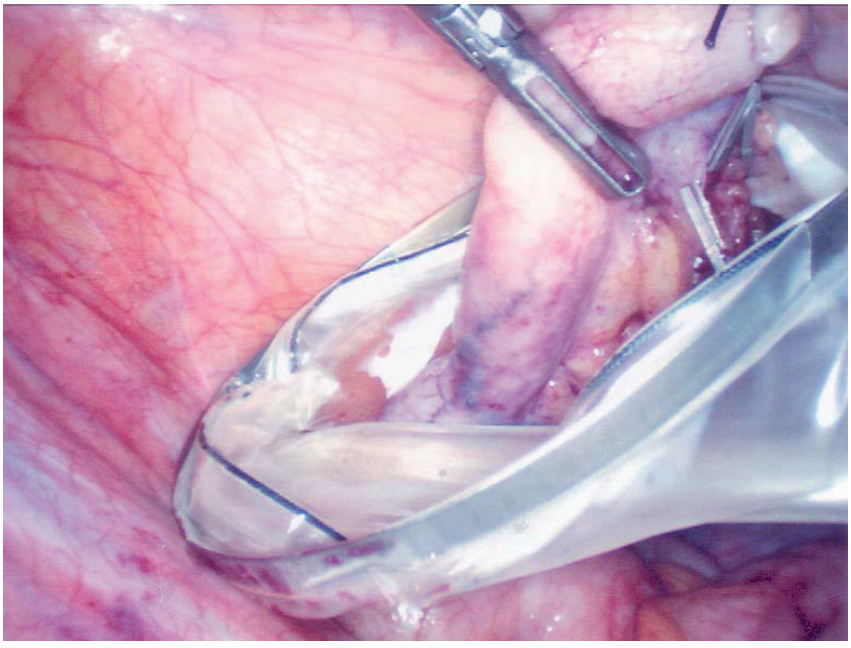

Figure 10

ONE-TROCAR APPENDECTOMY

The one-trocar appendectomy is an alternative for conventional laparoscopic or open appendectomy. In patients with a midline scare owing to previous abdominal surgery one-trocar appendectomy is not advisable [23, 24, 25]. Conversion from a one-trocar appendectomy to conventional multiple-trocar laparoscopic appendectomy is necessary in 16 to 24% of all patients. Of these converted patients, 25% undergo a second conversion to open surgery. The potential advantages of one-trocar appendectomy are avoidance of multiple scars and the ability to perform appendectomy in an open fashion, which is of benefit to surgeons who have less laparoscopic experience. However, prospective studies are required to determine the value of a one-trocar appendectomy in terms of safety and efficiency. A one-trocar appendectomy requires the presence of a surgical team that has been trained and is proficient in basic laparoscopic skills and the availability of high-quality videoscopic imaging. Information about the procedure is the same as described in the previous section on laparoscopic appendectomy. Positioning of the patient and the surgical team, in combination with the antibiotics, is also the same as in the conventional laparoscopic appendectomy setting. To establish a pneumoperitoneum, we use the open technique described earlier for the laparoscopic technique. For this technique, a special 10 mm 0^{o} Storz telescope is introduced (figure 11). This telescope is a combination of a scope and an operative channel. The scope is delivered with special long instruments, which are 49 cm longer than normal laparoscopic instruments (figure 12, 13). After inspection of the abdominal cavity, an atraumatic grasper is used to retract the small bowel loops and omentum, and a dissection instrument is used for further inspection and gentle preparation. When the appendix is located
posteriorly to the cecum, a one-trocar appendectomy is not possible. Inserting another instrument is necessary to retract the cecum. Once the appendix is completely free, the mesoappendix is grasped at the top, if this is impossible, then an endoloop is placed around the tip of the appendix. Pneumoperitoneum is released, and the appendectomy is performed outside the abdomen by pulling the appendix through the infraumbilicale incision, together with the trocar. The mesoappendix is ligated step by step. To allow good exposure, the abdominal wall is retracted by narrow-shaped retractors. The appendix is transected after ligation. Inverting the appendiceal stump by a purse-string suture or Z suture is not necessary. After completion of the appendectomy, the Hasson trocar is reinserted to allow laparoscopic inspection of the peritoneal cavity. Remaining pus or blood can be aspirated and irrigation of the peritoneal cavity can be performed. Furthermore, one should confirm by inspection of the length of the appendiceal stump that a complete appendectomy has been performed. Partial appendectomy can occur when visualization of the base of the appendix during the open phase of the procedure is difficult. In adults it is not always possible to obtain sufficient mobilization of the cecum to retract the appendix outside the abdomen, especially with patients who have a lot

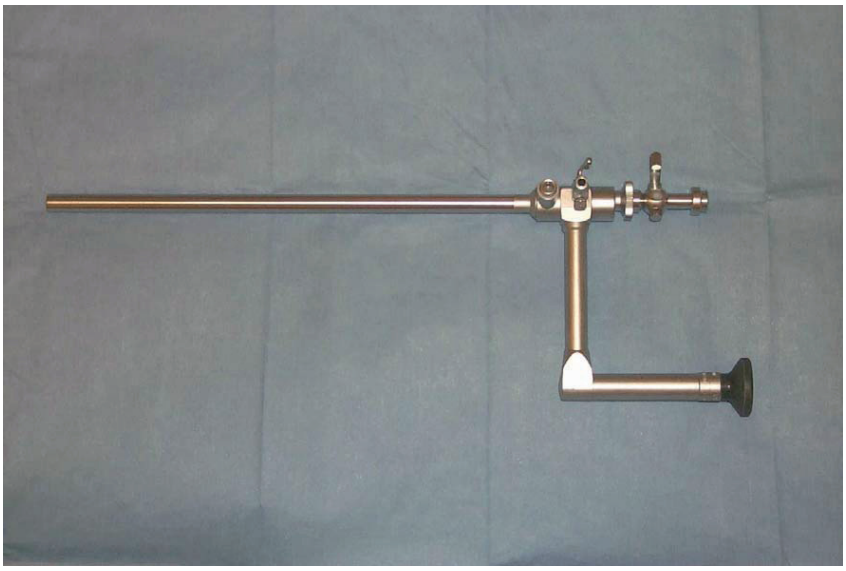

Figure 11

subcutaneous fat. For this reason, a one-trocar appendectomy is most suitable in children and slender patients.

Figure 12

Figure 13

POSTOPERATIVE CARE

The postoperative diet of patients is always on demand. For patients with a perforating appendicitis, 5 days intravenous antibiotic use is advisable. In a randomized trial of 94 patients, Taylor and colleagues concluded that antibiotics should be given on demand [25]. One group was given antibiotics for a minimum of 5 days and the other group was given antibiotics on the basis of clinical conditions. Infection complications were not statistically different in the groups, antibiotic use on demand led to less intravenous antibiotic use. In cases in which postoperative fever occurs, imaging of the abdomen by CT is advisable if there are no signs of wound infection. In cases of intra-abdominal abscess, percutaneous drainage is the treatment of choice. In cases of high fever and persisting abdominal pain without abscess on imaging techniques, a relaparoscopy should be considered. In the literature, the average hospital stay is 2.2 days, although some studies describe appendectomy as day surgery.

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Chapter 8

Carcinoid tumor of the appendix: an analysis of 1,485 consecutive emergency appendenctomies

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ABSTRACT

Aim: The aim of this study is to conduct a retrospective analysis of the incidence and long-term results of carcinoid tumours of the appendix in emergency appendectomies.

Methods: A retrospective review of 1,485 appendectomies performed in two centres from January 2000 until January 2006. Demographic data, clinical presentation, histopathology, operative reports and survival were scored and compared with the literature.

Results: In three women and four men, carcinoid tumours were identified (0,47%). The mean age was 32.7 years (range, 20-59 years). The clinical presentation was resembling the symptoms of acute appendicitis in all cases. Laparoscopic appendectomy was the treatment of choice in five patients; in one of these patients, a conversion to laparotomy was necessary. The other two patients underwent primary open appendectomy. Five patients underwent additional surgery after the pathology report became available. Four patients underwent ileocecal resection; one other patient underwent right hemicolectomy. In none of the re-operation specimens residual carcinoid tumour was detected. After a mean follow-up of 65 months (range, 25-92) all patients were alive and disease- and symptom free.

Conclusion: Carcinoid tumours of the appendix most often present as acute appendicitis. It also emphasises the value of histopathological analysis of every removed appendix. The long-term prognosis of incidentally found carcinoids of the appendix is good.

INTRODUCTION

Carcinoid tumour of the appendix is one of the most common single presentations of this type of tumour and is thereby the most common type of primary malignant lesions of the appendix.[1] The ileum is the second common site of presentation.[1] The carcinoid tumours of the appendix are often asymptomatic and found by chance during appendectomy or other abdominal operations. Carcinoid tumours are found in 0.3-0.9% of patients undergoing appendectomy.[1,2] Tumour characteristics predict the behaviour of the tumour.[2,7] The majority of patients with a incidental carcinoid are cured by appendectomy. The recommendation in literature for adjuvant surgery are irradical resection margins, tumour size greater than 2 cm and goblet-type of carcinoid.[9] Most surgeons will encounter this clinical problem only once in a lifetime. For this reason, in our opinion, even a small database will be a useful aid for the management of primary carcinoid tumours of the appendix. In this study, we aim for retrospective analysis of the incidence and long results of carcinoid tumours of the appendix in emergency appendectomies.

MATERIALS AND METHODS

The study is a retrospective analysis of patients undergoing appendectomies performed between January 2000 till January 2006 in the Erasmus University Medical Centre (ErasmusMC) and the Medical Centre Rijnmond Zuid (MCRZ), a Rotterdam community teaching hospital. Data were reviewed on demography, clinical presentation, histopathology, operative reports and long-term outcomes. The used definition of acute appendicitis was granulocyte infiltration through all layers of the appendiceal wall. The follow-up contained, medical history, blood samples and octreotide imaging or CT scan. Outpatient clinical controls were at least twice a year.

RESULTS

In the study period, 1,485 patients underwent a laparoscopic or open appendectomy for suspected acute appendicitis. The histopathology of seven patients showed carcinoid tumour.All specimen of those seven patients showed acute appendicitis as well. Of those seven patients, four were men and three were women. They had a mean age of 32.7 years (range, 20-59 years). In five patients, laparoscopic appendectomy was performed; in one of these patients, conversion was necessary because of anatomical reasons. Two patients underwent primary open appendectomy, one because of technical reasons and the other patients because of a ventriculoperitoneal drain. In six patients, the diagnosis was carcinoid; in one patient the histopathology showed a goblet type carcinoid. In four patients, the tumour was located at the tip of the appendix. In

two cases, the tumour was located at the base and in one in the body of the appendix. In two patients, tumour diameter was greater than 2 cm, and in one of these, a micro- metastasis was found in the mesentery of the appendix. Two other patients had positive resection margins at the base of the appendix. Four of these patients underwent ileocecal resection, two laparoscopic and two open. One patient underwent laparoscopic right hemicolectomy. In none of the re-operation specimens, residual tumour activity was observed, and no lymph node involvement was seen. Mean lymph node harvest of 11 (range, 5-17). In the other two patients who underwent appendectomy and a tumour less than 1 cm, no re-intervention was performed. All patients have remained tumour-free during a mean follow up of 65 month (range, 25-92 months).

DISCUSSION

The prevalence of carcinoid tumour in patients undergoing emergency appendectomy is in our database 0.47%. The literature describes percentages between 0.3 -0,.9% and a little dominant occurrence in female patients.[1,2,3,4,5,6] Unusual is the predominance of male patients in our series-four to three- probably due to the small series. The mean age of presentation at 32 years is lower than large epidemiological studies suggesting an average diagnostic age between 38 and 49 years, even higher for the goblet type carcinoid tumour (52 versus 42 years), also possibly related to these small numbers.[5,6] All seven patients presented with acute appendicitis. Probably by the absence of liver metastasis, also in retrospection, no signs of carcinoid tumour could be detected. During appendectomy, in none of the patients, the suspicion of appendicular tumour was raised. In all cases, histopathology reflected an inflammatory response adjacent to the tumour. This pleas for routine pathology of all removed appendices in patients with macroscopically inflamed appendices. In four patients, the tumour was located at the tip of the appendix: in two cases at the base and in one in the body of the appendix. This in accordance with the literature. [4,8] Carcinoid tumours of the appendix rarely metastasise. [2,3,7] Sporadically extended metastasis disease of a carcinoid tumour of the appendix is described.[7] In a review, Goede et al. describe that acceptable indications for re-intervention represented by all lesions larger than 2 cm in diameter, histological evidence of mesoappendiceal extension, tumours at the base of the appendix with positive margins or involvement of the cecum, high grade malignant carcinoids and goblet-cell adenocarcinoids.[9] The recommended resection is represented by right hemicolectomy. The consensus that appendiceal carcinoid tumours with a size smaller than 2 cm after radical resection need no further treatment because of minimal metastatic behaviour was followed successfully in this series. In two patients with a tumour at the base of the appendix and a tumour size smaller than 2 cm with positive resection margin, ileocecal resection was performed. No tumour remains in this specimen was found. One patient with a tumour larger than 2 cm with angioinvasive growth, underwent right hemicolectomy. This specimen was also without residual tumour on pathology.

In the other patient with a tumour larger than 2 cm, ileocecal resection was performed. The patient with the goblet-type of tumour underwent also ileocecal resection with no evidence of residual tumour in the specimen. Goblet-cell carcinoids have a worse outcome than the other types of carcinoid tumours and frequently present with metastatic disease.[9,10,14] This patient with a follow up of 75 months had no recurrence of disease. Lymph from the appendix drains into retrocecal glands, iloecolic glands, along the iloecolic artery and, finally, to central glands at the base of the superior mesenteric artery. This knowledge gives sense to ileocecectomy for carcinoid of the appendix resecting also the ileocecal artery at its origin from the superior mesenteric artery. At least, it is worth mentioning that patients with carcinoid lesions have a notable risk of developing a synchronous or metachronous colorectal neoplasm up to 33%.[1,2,9,11] Although none of our patients yet developed a colorectal tumour follow up by colonoscopy should be recommended. From this database, it is concluded that long-term prognosis of incidentally found carcinoids of the appendix is good. It also emphasises the value of histopathological analysis of the removed appendix. In stead of right hemicolectomy, ileocecal resection seems to be the logical operation for tumours larger than 2 cm.

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Chapter 9

Summary and conclusion

Chapter 1 gives a short general introduction. The main research questions of this dissertation are also described.

In **Chapter 2** the outcomes of a prospective study are presented. In this study, preoperative a Computer Tomography (CT) scan without contrast was made in 103 patients suspected of acute appendicitis. Next, all patients were subjected to diagnostic laparoscopy carried out by a surgeon who had no knowledge of the CT scan report. In this study laparoscopy is used as golden standard. Before finishing laparoscopy the surgeon could read the CT scan report. According to the CT scan, 83 patients (80,5%) had appendicitis. During laparoscopy, however, 87 patients (84,5%) turned out to have appendicitis. Laparoscopy confirmed the CT scan results in patients who did not have appendicitis according to the CT scan. This resulted in a sensitivity of 95,4% and a specificity of 100% of the CT scan for the diagnosis of acute appendicitis. For 12 out of the 20 patients without an indication of appendicitis on CT another diagnosis was suggested. For all these patients this diagnosis was confirmed by laparoscopy and no additional pathology was found. This study shows that CT scan without contrast is a good predictor of the diagnosis of acute appendicitis.

In **Chapter 3** the learning curve for the assessment of CT scan without contrast for the diagnosis of acute appendicitis is described. It is of great importance that for application in daily practice adequate assessment of CT is not limited to experts. Although there is not always an expert present during working hours, during these hours correct diagnosis and treatment are required as well. All the scans of the 103 patients from the study described in chapter two were assessed by three groups of radiologists. Group A consisted of radiology residents trained in CT interpretation, group B consisted of staff radiologists, group C was represented by an expert radiologist. Laparoscopy was used as golden standard. The specificity in all three groups was similar: 94%, 94%, and 100%, respectively. There were considerable differences in sensitivity, 81%, 88%, and 95%, respectively. Other disorders in patients who did not have acute appendicitis were all diagnosed by the expert radiologist and, apart form 1 patient, by the other two groups. These results complicate the implementation of routine CT scan in daily practice, especially during working hours. It is recommended that in the absence of an expert radiologist diagnostic laparoscopy is carried out or clinical observation is turned to.

In **Chapter 4** the question which CT technique is to be preferred with patients who are suspected of having acute appendicitis, is answered. In order to be able to make this distinction in the best possible way, a literature study was carried out, in which three groups are formed; group 1 consisted of studies with CT scan without contrast, group 2 of CT scans with enteral contrast (rectal, oral), and group 3 of CT scans with intravenous (iv) contrast. After careful selection, data of 2,207 patients from 18 studies were examined; 1,089 patients in the group without contrast, 658 patients in the enteral group and 474 patients in the iv group. The only significant difference was observed with regard to sensitivity between the iv contrast group and the group without contrast, in favor of CT scan with iv contrast. For specificity no difference was shown. The negative predictive value was better in both contrast groups in compari-

son with CT scans without contrast. The above data suggest that CT with iv contrast are to be preferred with patients who are suspected of acute appendicitis.

In **Chapter 5** a prospective study is described in which the actual costs of laparoscopic and open appendectomy are examined. In two hospitals the actual costs per patient were scored. One of the hospitals carried out laparoscopic appendectomy as a standard operation, the other hospital open appendectomy. Staff time investment, use of equipment and materials during operation, duration of admission and the number of visits to the outpatient clinic were measured. The conclusion was that laparoscopic appendectomy is more expensive for the hospital than open appendectomy, which is caused by higher costs during surgery. However, quicker recovery could decrease sickness absence after laparoscopic appendectomy, which might make the costs for the society comparable.

In **Chapter 6** one-trocar appendectomy is described with a cohort of 22 patients. Apart from the cosmetic advantage, one-trocar appendectomy has the advantage to insert an additional dissection instrument through the infraumbilically inserted optical trocar. With the help of this instrument dissection of the appendix takes place, after which open appendectomy through the infraumbilical incision can be carried out. The conclusion was that in adults this proved to be a difficult technique because often the appendix could not be mobilized adequately in order to be removed infraumbilically. In children and slim young adults it proved to be a good and safe technique, which required an experienced laparoscopy team.

In **Chapter 7** several treatment techniques for acute appendicitis are described. The chapter is mainly based on the personal experiences of the authors. All stages of acute appendicitis are dealt with, from the preoperative work-up to the postoperative follow-up, including all steps in between.

In **Chapter 8** a retrospective analysis of 1,482 appendectomies is carried out. The central question was whether or not histopathological assessment is necessary after macroscopic acute appendicitis. A malignancy was found in seven patients in this series, all were cases of carcinoid tumors. Five out of the seven patients turned out to be in need of curative surgery after the final diagnosis was made. After an average follow-up of 65 months all patients were disease free. The conclusion is that histopathological assessment is recommended with all removed appendices. It is also concluded that the long-term prognosis of accidentally found carcinoid tumors of the appendix is good.

CONCLUSION

In our present healthcare system with guidelines and evidence-based medicine the care for acute appendicitis has to follow suit. This dissertation shows that in the work-up of patients with suspected acute appendicitis CT scan plays an important role. CT scan with intravenous contrast is to be preferred. In daily practice however, the lack of experience of the radiologist

in the assessment of CT scans can be a limiting factor. If (tele)supervision by an expert radiologist is not possible diagnostic laparoscopy is advised. If adequate laparoscopic experience and the right set of instruments are present, in children even one-trocar appendectomy can even be considered. It is important that all removed appendices are sent to the pathologist in order to prevent the pssibility of missing a malignancy. In the present discussion about health care in The Netherlands the issue of costs is becoming increasingly important. This dissertation shows that laparoscopic appendectomy is more expensive than open appendectomy. The higher costs are mainly made during the operation itself, while quicker recovery and resumption of work will probably create lower macro-economic costs. Furthermore laparoscopy has the advantage that it can be used as a diagnostic tool and therefore it can prevent unnecessary costs of the removal of a normal appendix. And even more important the occurence of long term complications is reported to be lower after laparoscopic appendectomy.

Chapter 10

Nederlandse samenvatting

Hoofdstuk 1 geeft een korte algemene inleiding. De belangrijkste vraagstukken van dit proefschrift worden beschreven.

In **Hoofdstuk 2** worden de resultaten gepresenteerd van een prospectief opgezette studie. Hierin werd bij 103 patiënten, die door de chirurg verdacht werden van appendicitis acuta, preoperatief een Computer Tomography (CT) scan zonder contrast gemaakt. Vervolgens werd bij alle patiënten een diagnostische laparoscopie verricht door een chirurg die niet op de hoogte was van het verslag van de CT scan. De laparoscopie werd in deze studie als gouden standaard gehanteerd. Voordat de chirurg de laparoscopie beëindigde kon het CT verslag worden gelezen. Bij 83 patiënten (80,5%) werd op de CT scan appendicitis geconstateerd. Tijdens laparoscopie bleken echter 87 patiënten (84,5%) appendicitis acuta te hebben. Bij alle patiënten bij wie op de CT scan geen appendicitis acuta geconstateerd werd, werd dit door de laparoscopie bevestigd. Dit resulteerde in een sensitiviteit van 95,4% en een specificiteit van 100% van de CT scan voor de diagnose appendicitis acuta. Bij 12 van de 20 patiënten zonder aanwijzingen voor appendicitis op de CT werd een andere diagnose gesuggereerd. Bij al deze patiënten werd deze diagnose bij laparoscopie bevestigd en werd geen additionele pathologie gevonden. Deze studie laat zien dat de CT scan zonder contrast de diagnose appendicitis acuta goed kan voorspellen.

In **Hoofdstuk 3** wordt de leercurve voor het beoordelen van de CT scan zonder contrast voor de diagnose appendicitis acuta besproken. Voor toepassing in de dagelijkse praktijk is het namelijk van groot belang dat de beoordeling van een CT scan niet alleen door experts adequaat kan worden verricht. Want hoewel in diensturen niet altijd een expert aanwezig is, is ook gedurende deze uren een correcte diagnose en behandeling vereist. Alle CT scans van de 103 patiënten uit de in hoofdstuk 2 beschreven studie werden door drie groepen radiologen beoordeeld. Groep A bestond uit ouderejaars assistenten in opleiding tot radioloog, groep B bestond uit stafradiologen, groep C werd gevormd door een expert-radioloog. De laparoscopie werd gebruikt als gouden standaard. De specificiteit in alle drie de groepen was vergelijkbaar: respectievelijk 94%, 94% en 100%. De sensitiviteit verschilde echter aanzienlijk: respectievelijk 81%, 88% en 95%. Overige aandoeningen bij patiënten die geen appendicitis acuta hadden werden allemaal door de expert-radioloog gediagnosticeerd en op 1 na door de overige twee groepen. Deze resultaten maken het implementeren van de routine CT scan zonder contrast in de dagelijks praktijk, met name tijdens diensturen, moeizaam. Het is aan te raden om bij de afwezigheid van een expert-radioloog een diagnostische laparoscopie uit te voeren of over te gaan op klinische observatie.

In **Hoofdstuk 4** wordt geprobeerd een oplossing te vinden voor het vraagstuk welke CT techniek te prefereren is bij patiënten die verdacht worden van appendicitis acuta. Om dit onderscheid goed te kunnen maken werd een literatuurstudie verricht. Hierbij werden 3 groepen gemaakt; groep 1 bestond uit studies met een CT scan zonder contrast, groep 2 uit CT scans met enteraal contrast (rectaal, oraal) en groep 3 uit CT scans met intraveneus (iv) contrast. Na nauwkeurige selectie werden data van 2207 patiënten uit 18 studies bestudeerd; 1089 patiën-

ten in de groep zonder contrast, 658 patiënten in de enterale groep en 474 patiënten in de iv groep. Het enige significante verschil werd gevonden in sensitiviteit tussen de iv contrast groep en de groep zonder contrast, ten faveure van de CT met iv contrast. Voor de specificiteit werd geen verschil aangetoond. De negatief voorspellende waarde is beter in beide contrastgroepen ten opzichte van CT scans zonder contrast. Bovenstaande gegevens suggereren dat CT scanning met iv contrast de voorkeur heeft bij patiënten met verdenking op appendicitis acuta.

In **Hoofdstuk 5** wordt een prospectieve studie beschreven waarin gekeken werd naar de werkelijke kosten van laparoscopische en open appendectomie. In een tweetal ziekenhuizen werden de werkelijke kosten per patiënt gescoord. Het ene ziekenhuis verrichtte als standaard operatie laparoscopische appendectomie, het tweede ziekenhuis open appendectomie. Tijdsinzet van personeel, apparatuur- en materiaalgebruik bij operatie, opnameduur en aantal polikliniekbezoeken werden gemeten. Geconcludeerd werd dat laparoscopische appendectomie duurder is voor het ziekenhuis dan open appendectomie, dit wordt veroorzaakt door hogere operatiekosten. Echter, door een sneller herstel zou het ziekteverzuim na een laparoscopische appendectomie lager kunnen uitvallen waardoor de kosten voor de maatschappij mogelijk vergelijkbaar zijn.

In **Hoofdstuk 6** wordt de one-trocar appendectomie bij een cohort van 22 patiënten beschreven. De one-trocar techniek heeft naast de cosmetiek als groot voordeel dat het de mogelijkheid biedt om door een infraumbilicaal ingebrachte optische trocar een extra dissectie instrument in te brengen. Met behulp van dit instrument vindt dissectie van de appendix plaats waarna open appendectomie door de 12mm grote infraumbilicale incisie kan worden verricht. Concluderend bleek dit een lastige techniek bij volwassenen doordat de appendix vaak slecht te mobiliseren bleek om infraumbilicaal te verwijderen. Bij kinderen en slanke jong volwassenen bleek het wel een goede en veilige techniek waarbij een ervaren laparoscopisch team een vereiste was.

In **Hoofdstuk 7** worden de diverse behandeltechnieken bij appendicitis acuta besproken waarbij de basis van het hoofdstuk met name is gebaseerd op de persoonlijke ervaring van de auteurs. Alle fasen van appendicitis acuta komen aan de orde, van de preoperatieve work up tot de postoperatieve follow up met alle daartussen liggende stappen.

In **Hoofdstuk 8** vindt een retrospectieve analyse van 1482 appendectomieën plaats. De vraag of histopathologisch onderzoek na macroscopische appendicitis acuta wel noodzakelijk is staat hierin centraal. Bij zeven patiënten uit deze serie werd een maligniteit gevonden, het ging in alle gevallen om een carcinoïd tumor. Vijf van de zeven patiënten bleken na het stellen van de definitieve diagnose aanvullende curatieve chirurgie nodig te hebben. Na een gemiddelde follow up van 65 maanden waren alle patiënten ziektevrij. De conclusie was dat histopathologisch onderzoek bij alle verwijderde appendices aan te bevelen is. Ook wordt geconcludeerd dat de lange termijn prognose van bij toeval gevonden carcinoïd tumoren van de appendix goed is.

CONCLUSIE

In het huidige zorgsysteem met richtlijnen en evidence based medicine mag de kwaliteit van zorg met betrekking tot appendicitis acuta niet achterblijven. Dit proefschrift laat zien dat in de work up van patiënten met verdenking op appendicitis acuta de CT scan een belangrijke rol heeft. Bij voorkeur betreft het een CT scan met intraveneus contrast. In de dagelijkse praktijk kan de beperkte ervaring van de radioloog met het beoordelen van CT scans echter een beperkende factor zijn. Indien (tele)supervisie door een expert radioloog niet mogelijk is wordt een diagnostische laparoscopie geadviseerd. Bij kinderen kan zelfs worden overwogen om bij voldoende laparoscopische ervaring en indien het juiste instrumentarium voorhanden is one-trocar appendectomie te verrichten. Belangrijk is om in ieder geval alle preparaten voor histopathologisch onderzoek op te sturen om de kans op het missen van een maligniteit te voorkomen. In de huidige discussie over de zorg in Nederland worden kosten steeds belangrijker. Uit dit proefschrift blijkt laparoscopische appendectomie duurder dan open appendectomie. De hogere kostprijs wordt met name veroorzaakt gedurende de operatie zelf, terwijl een sneller herstel en vroegere werkhervatting waarschijnlijk voor lagere macro-economische kosten zorgen. Daarnaast heeft laparoscopie een groot voordeel dat het ook als diagnosticum gebruikt kan worden en derhalve onnodige kosten voor het verwijderen van een niet ontstoken appendix kan voorkomen.

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CURRICULUM VITAE

Klaas-Hendrik in't Hof werd geboren op 11 mei 1970 te Bathmen. Na het behalen van zijn VWO diploma op de Scholengemeenschap Holten te Holten in 1988, studeerde hij 1 week economie aan de Erasmus Universiteit Rotterdam. Aansluitend studeerde hij Geneeskunde aan de Universiteit Utrecht en legde eind 1996 zijn artsexamen af. Nadat hij als arts-assistent niet in opleiding in de Weezenlanden en het Erasmus Medisch Centrum had gewerkt, startte hij zijn opleiding Heelkunde in 2000. Zijn opleiding begon in het toenmalige St. Clara Ziekenhuis te Rotterdam (opleider dr. T.Y. Yo, opgevolgd door dr. J.F. Lange). De opleiding vervolgde hij vanaf 2004 in het Erasmus MC (opleider prof. H.J. Bonjer, opgevolgd door prof. J.N.M. IJzermans). Gedurende zijn opleiding werkte hij aan de voltooiing van zijn proefschrift. Vanaf januari 2006, na afronding van zijn opleiding, werkte hij gedurende 9 maanden als chef de clinique in het Diakonessenhuis te Utrecht. In oktober 2006 startte hij zijn chivo-schap chirurgische oncologie in het Eramus MC met als opleiders J.H.W. de Wilt en C.H.J. van Eijck. Sinds 1 maart 2009 werkt hij als chirurg in het Flevoziekenhuis te Almere en voor 20% in het Academisch Medisch Centrum Amsterdam. Zijn aandachtsgebieden zijn de oncologische en endocriene chirurgie. Klaas-Hendrik woont gelukkig samen met Nathalie Dingeldein en heeft twee prachtige kinderen: Bella en Tjebbe.


I WINT