

The role of computed tomography in clinically-suspected but equivocal acute appendicitis

A C C Poh, M Lin, H S Teh, A G S Tan

ABSTRACT

Introduction: To study the role of contrast-enhanced computed tomography (CT) of the abdomen and pelvis in the evaluation of patients with clinically-suspected but equivocal acute appendicitis.

Methods: The medical records of 206 consecutive patients who had CT of the abdomen and pelvis for equivocal signs and symptoms of acute appendicitis were reviewed. 7mm collimated axial sections from the diaphragm to the iliac crest and 5mm collimated sections of the pelvis with intravenous and oral contrast were obtained. The criteria used to diagnose acute appendicitis were: (a) a thickened appendix of more than 7mm or (b) inflammatory changes in the periappendiceal fat. The CT findings were correlated with the histological diagnosis at appendectomy. If the CT findings were negative for acute appendicitis and surgery not performed, the results were correlated with other corroborating diagnostic investigations or clinical follow-up.

Results: A total of 206 patients were scanned, of which 39 were excluded due to lack of any follow-up. Of the final 167 that were studied, there 36 true positives, 127 true negatives, 4 false negative and no false positives, resulting in a sensitivity of 93.9 percent, specificity of 100 percent and accuracy of 98.5 percent.

Conclusion: We have found CT to be a safe, reliable and accurate modality in the diagnosis of acute appendicitis in patients with equivocal presentation.

Keywords: acute abdomen, acute appendicitis, computed tomography

Singapore Med J 2004 Vol 45(8):379-384

INTRODUCTION

Acute appendicitis is the most common cause of acute abdominal pain requiring surgery in the developed world⁽¹⁾. Although most cases of acute appendicitis can be diagnosed correctly with meticulous history-taking

and physical examination, 22-33% of patients do not present with typical signs and symptoms and accurate diagnosis can be difficult even in the hands of experienced clinicians⁽²⁾. Moreover, there are many other conditions that can mimic appendicitis, some of which may not require urgent surgery. Prompt and accurate diagnosis is required to avoid the morbidity and mortality in patients who have acute appendicitis and to avoid unnecessary appendectomies in patients who do not.

Computed tomography (CT) has been shown to be accurate in the diagnosis of acute appendicitis⁽⁴⁻¹²⁾ but its exact role as a diagnostic aid in daily clinical practice is still being defined⁽⁴⁾. Some authors believe that the liberal use of CT in all patients with suspected appendicitis would help decrease the negative appendectomy rates which have been as high as 30% in the pre-CT era⁽¹³⁻¹⁵⁾. Others feel that CT does not improve and may even delay the diagnosis and treatment of acute appendicitis⁽¹⁶⁻¹⁷⁾. Another group favours its use in a select group of patients with confusing presentations, particularly among the elderly and women of reproductive age^(2,18,19, 21). They advocate imaging in clinically-equivocal patients to reduce the rate of perforation, unnecessary appendectomies, observation time as well as to promptly institute treatment based on imaging diagnosed alternative conditions.

Our purpose is to examine the role CT assumes in the surgical evaluation of clinically-suspected but equivocal acute appendicitis in the setting of a busy secondary general hospital in Singapore. We wish to determine the usefulness of this diagnostic tool and establish whether these results should influence our current clinical management pathway in these patients.

METHODS

The medical records of all patients who underwent CT of the abdomen and pelvis for suspected acute appendicitis over a three year and seven month period (between July 1997 to January 2001) in our institution were reviewed. Patients were referred by the attending surgeon for imaging when the

Department of
Diagnostic
Radiology
Changi General
Hospital
2 Simei Street 3
Singapore 529889

A C C Poh, MBBS,
MMed, FRCR
Registrar

M Lin, MBBS,
MMed, FRCR
Consultant

H S Teh, MBBS, FRCR
Consultant

A G S Tan, MBBS,
FRCR
Consultant

Correspondence to:
Dr A C C Poh
Tel: (65) 6850 4849
Fax: (65) 6260 1703
Email: shirodka@
yahoo.co.uk

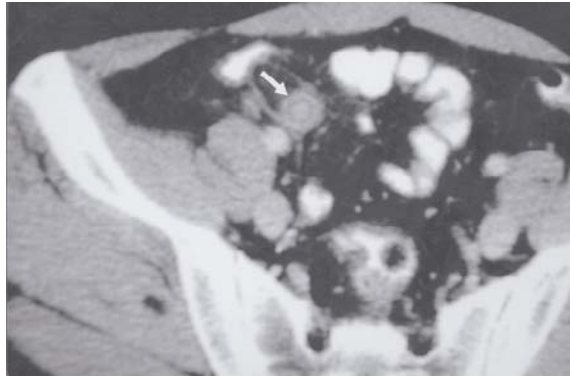


Fig. 1 Enhanced axial CT image shows a dilated 1.2cm appendix with periappendiceal stranding (arrow).

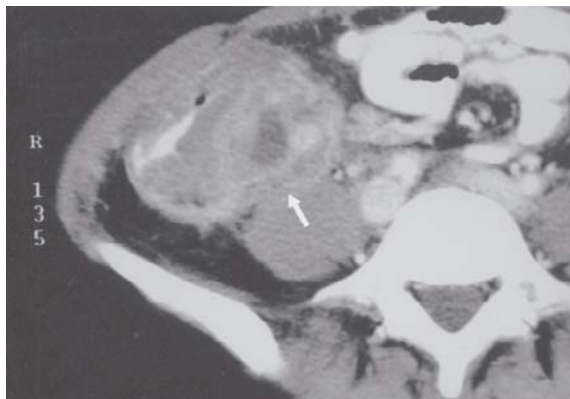


Fig. 2 Enhanced axial CT image shows an appendiceal abscess (arrow).

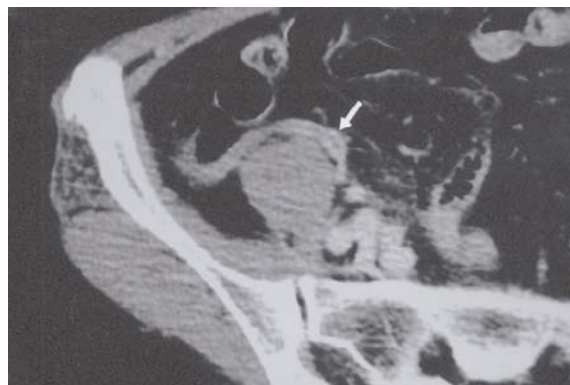


Fig. 3 Enhanced axial CT image shows enhancement of the body and tip of the appendix (arrow).

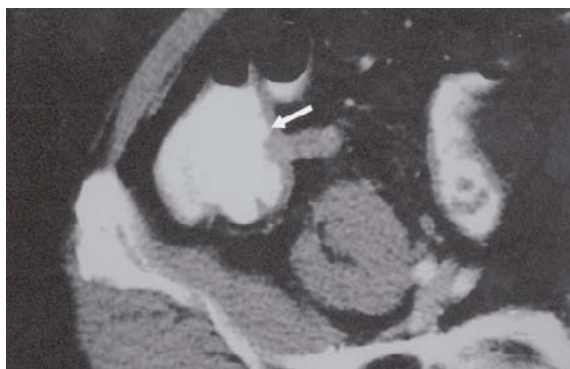


Fig. 4 Enhanced axial CT image shows an arrowhead-shaped collection of contrast near the orifice of the appendix, the so-called "arrowhead" sign (arrow)

clinical features were considered insufficient for a definitive diagnosis of acute appendicitis as defined by Weltman et al, i.e. absence of definite signs of peritonism in the right iliac fossa (RIF), fever, vomiting or leucocytosis⁽²⁾. All patients with classical presentations for acute appendicitis (i.e. definite signs of RIF peritonism, fever, vomiting, leucocytosis) underwent immediate surgery and were not included in the study. We included patients who had histological diagnosis, or other corroborating diagnostic investigation (e.g. ureteroscopy for urolithiasis). If surgery or other corroborating diagnostic investigation was not performed, clinical follow-up on all such patients had to be performed to ensure that the patient did not develop acute appendicitis after discharge.

All scans were performed using a helical CT scanner (HiSpeed CTi, GE Medical Systems, Milwaukee, USA). A standard CT protocol consisting of three doses of oral contrast agent consisting of 250 ml 2.5% w/v meglumine ioxitalamate (Telebrix 300), each given at half hourly interval and one just before the start of the scan. 200 ml of rectal contrast consisting of 2.5% w/v meglumine ioxitalamate (Telebrix 300) was also introduced. A tampon was inserted for female patients. 100ml of intravenous contrast (Omnipaque 350) was administered at a rate of 2 ml/sec. Scan delay of 65 seconds was used to allow optimal opacification of vessels and the appendix. Helical acquisition was obtained at 7mm collimation from the diaphragmatic dome to the iliac crest and followed by 5mm collimation of the pelvis (pitch 1.6, 120kVp, 240-270mA). Additional fine 3mm collimation scans to further evaluate any suspicious lesion were performed at the discretion of the attending radiologist.

The primary criteria used to establish the diagnosis of acute appendicitis was: (a) a thickened appendix of more than 7mm diameter (Fig. 1) or (b) inflammatory changes in the periappendiceal fat e.g. stranding, thickening of the lateral conal fascia, phlegmon or abscess (Fig. 2). Other secondary features of acute appendicitis such as appendiceal wall enhancement (Fig. 3), caecal wall thickening e.g. focal thickening, arrowhead sign (Fig. 4), appendicolith (Fig. 5) or adenopathy was also noted. The CT findings were noted and these were correlated with the histological diagnosis (Fig. 6), corroborating diagnostic investigation or clinical follow-up. All scans had been reported by the attending radiologist and were also retrospectively reviewed by an independent radiologist to determine the reasons for any incorrect interpretation.

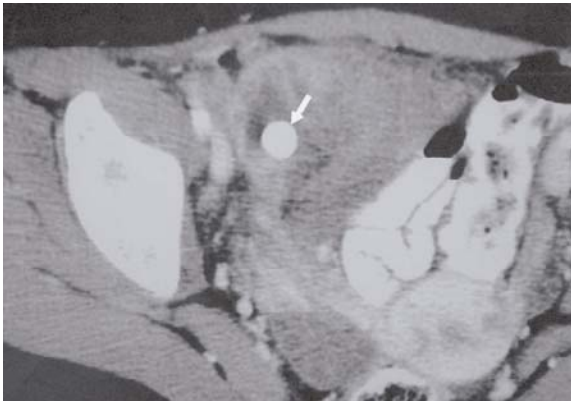


Fig. 5 Enhanced axial CT image shows a dense appendicolith in a patient with perforated appendicitis (arrow). There is a periappendiceal inflammatory mass.

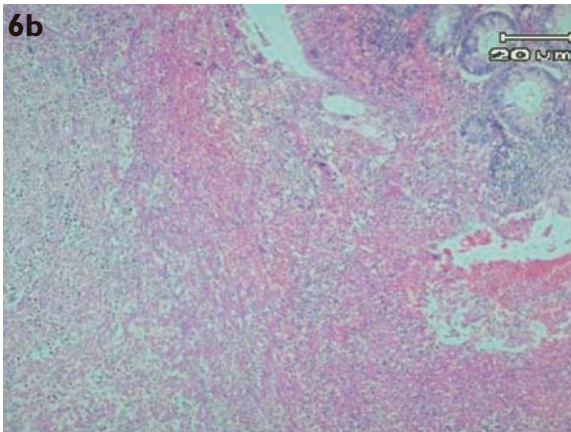
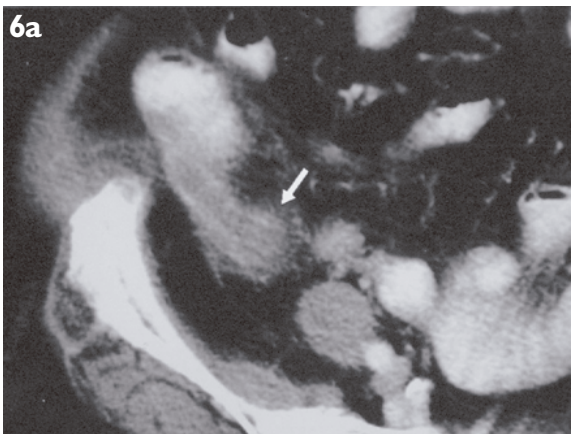


Fig. 6 (a) Enhanced axial CT image shows a dilated appendix with appendiceal stranding (arrow). (b) Photomicrograph shows acute suppurative appendicitis (Haematoxylin & eosin, x 240).

Table I. Summary of results of CT diagnosis.

	Final diagnosis - positive appendicitis	Final diagnosis - negative appendicitis	Total no. of patients
CT-positive appendicitis	36	0	36
CT-negative appendicitis	4	127	131
Total no. of patients	40	127	167

RESULTS

A total of 206 patients were scanned, of which 39 had to be excluded due to lack of any follow-up. These included 37 patients who did not have acute appendicitis on CT and did not return for their outpatient review. There were two patients with positive CT diagnosis of appendicitis in this group. One died of multiple medical problems before surgery. One discharged himself to return to his own country for further treatment.

In the final 167 patients, there were 97 females and 70 males who ranged in age from 14 to 86 (mean age 45.6) years. These comprised 36 true positive cases, 127 true negatives and four false negatives. No false positive case was found (Table I). This analysis yielded a sensitivity of 90%, specificity of 100%, and an accuracy of 98%. The positive predictive value was 100% and the negative predictive value was 96.9%.

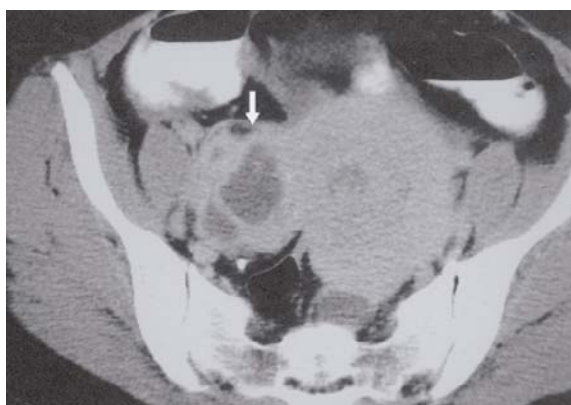
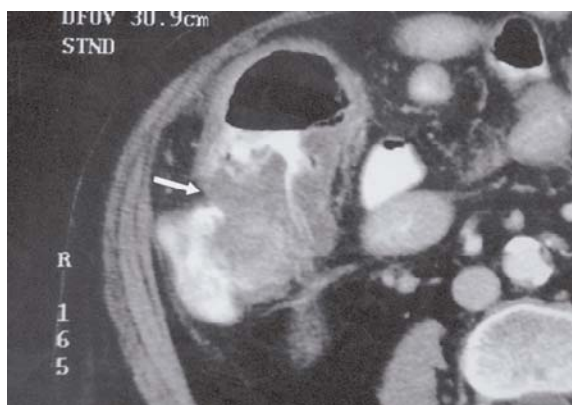
All the four false negative cases had worsening of clinical symptoms and had subsequent surgery. Of the four patients who had false negative scans, the initial CT interpretation included one case of mesenteric adenitis, one case with normal CT findings, one case of carcinoma of the hepatic flexure with inflammatory changes in the ascending colon, and one case of a thickened appendix due to previous inflammation (Table II). In the first two patients, the normal appendix could not be identified due to lack of intraperitoneal fat but there was no periappendiceal sign of inflammation. In the third patient, the normal appendix could not be identified due to the pericolic inflammation and thickening of the ascending colon. The last patient was encountered early in the study

Table II. Four cases of false-negative CT diagnosis of acute appendicitis.

CT diagnosis	Visualisation of appendix	Histological diagnosis
Normal appendix	No	Acute appendicitis
Mesenteric adenitis	No	Early acute appendicitis
Carcinoma of the hepatic flexure with inflammatory changes in the ascending colon	Yes	Acute appendicitis
Previous appendiceal inflammation	No	Perforated appendicitis with abscess

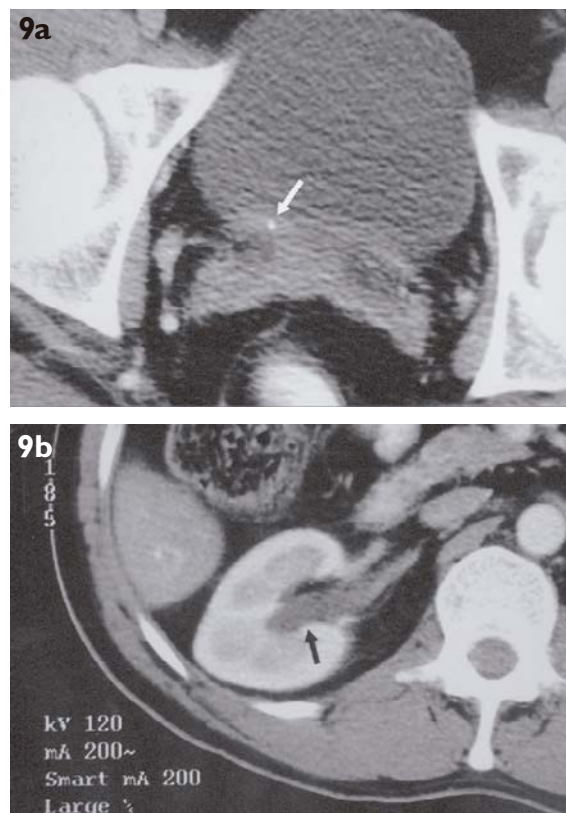
Table III. Alternative CT diagnosis correctly established on the basis of histology or other diagnostic investigation.

Diagnosis	No. of patients	% of patients
Diverticulitis	12	29
Ovarian tumour	7	17
Colitis	6	14
Colonic tumour	5	12
Tubo-ovarian abscess	4	10
Pyelonephritis	3	7
Urolithiasis	3	7
Appendiceal tumour	1	2
Acute cholecystitis	1	2
Total	42	100

**Fig. 7** Enhanced axial CT image shows a complex cystic right adnexal mass in a young woman presenting with right iliac fossa pain (arrow). A tubo-ovarian abscess was found intra-operatively.**Fig. 8** Enhanced axial CT image shows an eccentric thickening of the caecum in an elderly man presenting with right iliac fossa pain for two days (arrow). This was correctly interpreted as caecal carcinoma.

and on retrospect, was regarded as an obvious case of acute appendicitis.

In 82 of the 167 patients, CT identified alternative or incidental pathology. In 42 (50%) of these 82 patients, CT correctly established alternative diagnoses that mimicked acute appendicitis based on histological

**Fig. 9** Enhanced axial CT images of a man with acute right iliac fossa pain. (a) A small calculus was seen at the right vesicoureteric junction (white arrow). (b) There was corresponding mild dilatation of the right ureter and renal pelvis (black arrow).

diagnosis or other corroborating diagnostic investigation (Table III). The more common disease entities encountered included 12 (29%) cases of diverticulitis, 11 (26%) cases of gynaecological pathology, e.g. ovarian tumours, pelvic inflammatory disease (Fig. 7), six (14%) cases of colitis and five (12%) cases of colonic cancer (Fig. 8). The remaining alternative diagnosis included urolithiasis (Fig. 9), pyelonephritis, appendiceal mucocoele (Fig. 10) and acute cholecystitis.

A total of 57 patients in our study population underwent appendectomies, including all 40 cases of acute appendicitis correctly diagnosed on CT. The remaining 17 patients underwent appendectomies due to worsening clinical symptoms. These included 10 patients who had normal appendices on CT without other demonstrable pathology, a case each of pyelonephritis, colitis, mesenteric adenitis, two patients with equivocal CT findings (normal appendix not seen, but no secondary features of acute appendicitis) and two patients with pelvic inflammatory disease (Table IV). These 17 patients had histologically-proven normal appendices, giving rise to an overall negative appendectomy rate of 30%. In women, the negative appendectomy rate was 40% (13 of 17) and 25% (4 of 15) in men. The difference between genders was however not statistically significant ($p=0.08$).

DISCUSSION

The task of making an accurate diagnosis of acute appendicitis based on clinical criteria alone, can be especially challenging when the patient presentation is not classical. Although a negative appendectomy rate of up to 15% has been considered reasonable in the past, these figures may now not be acceptable, with the advent of diagnostic tools such as CT⁽²⁰⁾.

In our study, we have found CT to be a safe, reliable and accurate modality in the diagnosis of acute appendicitis in this population of patients with equivocal presentation. Our findings of 90% sensitivity, 100% specificity and 98% accuracy mirror those of other large centres⁽⁴⁻¹²⁾. It is conceivable that the results might have been even better as there were 37 patients with negative appendicitis findings on CT and two patients with positive appendicitis findings who were excluded because of lack of follow-up. Moreover, there was a bonus of identifying other pathology that mimics acute appendicitis and allowed for more disease specific treatment in patients that would have otherwise undergone appendectomies^(2,18).

Although the American College of Radiology appropriateness criteria score of CT for patients with suspected acute appendicitis who are thin and are females of reproductive age is lower at six, compared to right lower quadrant (RLQ) graded-compression ultrasonography at eight, CT is still the preferred modality at our institution. The ability of CT to depict periappendiceal abscesses and other pathologies which may alter the management plan is of primary importance to our clinicians. Moreover, graded ultrasonography of the appendix is operator- and to some extent, patient- dependent. In pregnant patients however, RLQ graded-compression ultrasonography is the imaging modality of choice for suspected acute appendicitis as the radiation risk to the foetus is unacceptable. We rarely encounter such patients as they are typically not admitted to our institution.

There were four false negative cases, which highlights the point that CT does not excuse the surgeon from good clinical judgment, especially when a normal appendix is not identified on CT. Nevertheless, when a normal appendix is identified on CT, as in 15 of our patients who underwent appendectomies, the risk of acute appendicitis is low and the decision to operate should be a judicious one. This point is highlighted by the relatively-high overall negative appendectomy rate of 30% in our study population, compared to the rates of 4-16% achieved by other authors^(4,19,21). In addition, a higher proportion of patients with negative appendectomies are also women and although the gender difference is not statistically significant, it suggests that appropriate weightage

Table IV. CT diagnosis in patients who had histologically-proven normal appendices after appendectomies.

CT diagnosis	No. of patients
Normal appendix	10
Pyelonephritis	1
Colitis	1
Mesenteric adenitis	1
Equivocal*	2
Pelvic inflammatory disease	2
Total no. of patients	17

* Normal appendix not seen but no secondary features of acute appendicitis.

should be given to a negative CT scan, particularly in women, before surgery is undertaken.

In Singapore, where spiraling health care costs are a major concern, it is conceivable that CT in this select group of patients may reduce the financial toll on patients by reducing observation time, avoiding unnecessary appendectomies, and allowing prompt, diagnosis specific management. Some studies have shown the savings incurred by this improvement in patient care outweighs cost of routine appendiceal CT⁽¹⁴⁻¹⁵⁾. There is a need to study the cost-effectiveness of diagnostic tests such as CT in the context of the Singapore health care system. In conclusion, we believe that CT plays a critical role in the treatment of patients with clinically-suspected but equivocal acute appendicitis and we recommend its inclusion in the clinical management pathway.

ACKNOWLEDGEMENT

We wish to thank Professor Wilfred C G Peh for his invaluable assistance in the preparation of this manuscript.

REFERENCES

1. Irvin TT. Abdominal pain: a surgical audit of 1190 emergency admissions. *Br J Surg* 1989; 76:1121-5.
2. Wijetunga R, Tan BS, Rouse JC, Bigg-Wither GW, Doust BD. Diagnostic accuracy of focused appendiceal CT in clinically equivocal cases of acute appendicitis. *Radiology* 2001; 221:747-53.
3. Rao PM, Boland GWL. Imaging of acute right lower abdominal quadrant pain. *Clin Radiol* 1998; 53:639-49.
4. Birnbaum BA, Wilson SR. Appendicitis at the millennium. *Radiology* 2000; 215:337-48.
5. Balthazar EJ, Birnbaum BA, Yee J, Megibow AJ, Roshkow J, Gray C. Acute appendicitis: CT and US correlation in 100 patients. *Radiology* 1994; 190:31-5.
6. Horton KM, Corl FM, Fishman EK. CT evaluation of the colon: inflammatory disease. *Radiographics* 2000; 20:399-418.
7. Lane, MJ, Liu DM, Huynh MD, Jeffrey RB, Mindelzun RE, Katz DS. Suspected acute appendicitis: nonenhanced helical CT in 300 consecutive patients. *Radiology* 1999; 213:341-6.
8. Lane MJ, Mindelzun RE. Appendicitis and its mimickers. *Semin Ultrasound CT MRI* 1999; 20:77-85.
9. Birnbaum BA, Jeffrey RB Jr. CT and sonographic evaluation of acute right lower quadrant pain. *Am J Roentgenol* 1998; 170:361-71.

10. Birnbaum BA, Balthazar EJ. CT of appendicitis and diverticulitis. Radiol Clin North Am 1994; 32:885-98.
11. Mindelzun RE, Jeffrey RB. The acute abdomen: current CT imaging techniques. Semin Ultrasound CT MRI 1999; 20:63-7.
12. McDonough J, Stasik C 3rd, Piontkowsky D 4th, Treisman E. Can appendiceal CT scanning be utilized effectively in widespread general surgical practice? Am Surg 2002; 68:917-21.
13. Brandt MM, Wahl WL. Liberal use of CT scanning helps to diagnose appendicitis in adults. Am Surg 2003; 69:727-31. Discussion 731-2.
14. Rao PM, Rhea JT, Novelline RA, Mostafavi AA, McCabe CJ. Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. N Engl J Med 1998; 338:141-6.
15. Schuler JG, Shortsleeve MJ, Goldenson RS, Perez-Rossello JM, Perlmutter RA, Thorsen A. Is there a role for abdominal computed tomographic scans in appendicitis? Arch Surg 1998;133:373-6. Discussion 377.
16. Lee SL, Walsh AJ, Ho HS. Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. Arch Surg 2001;136:556-62.
17. Perez J, Barone JE, Wilbanks TO, Jorgenson D, Corvo PR. Liberal use of computed tomography scanning does not improve diagnostic accuracy in appendicitis. Am J Surg 2003; 185:194-7.
18. Weltman DI, Yu J, Krumenacker J Jr, Huang S, Moh P. Diagnosis of acute appendicitis: comparison of 5- and 10-mm CT sections in the same patient. Radiology 2000; 216:172-7.
19. Hershko DD, Sroka G, Bahouth H, Ghersin E, Mahajna A, Krausz MM. The role of selective computed tomography in the diagnosis and management of suspected acute appendicitis. Am Surg 2002; 68:1003-7.
20. Flum DR, Morris A, Koepsell T, Dellinger EP. Has misdiagnosis of appendicitis decreased over time? A population-based analysis. JAMA 2001; 286:1748-53.
21. Bendeck SE, Nino-Murcia M, Berry GJ, Jeffrey RB Jr. Imaging for suspected appendicitis: negative appendectomy and perforation rates. Radiology 2002; 225:131-6.

2004 SMA ANNUAL GOLF CHAMPIONSHIP

The 2004 SMA ANNUAL GOLF CHAMPIONSHIP will be held on **27 October 2004 (Wednesday)** at **Laguna National Golf and Country Club (LNGCC), Classic Course.**

As usual, players can look forward to excellent prizes. There will also be a buffet dinner at 7.30pm, Eagle room, after the golf competition.

The entrance fee is \$160 for non-LNGCC members and \$100 for LNGCC members.

Kindly send your participation reply-slip by **13 October 2004.**

To: Ms Karen Teo
Singapore Medical Association
2 College Road, Level 2
Alumni Medical Centre
Singapore 169850

Fax: 6224 7827 Email: karen@sma.org.sg

I wish to participate in the 2004 SMA Annual Golf Championship.

I am / am not * a member of LNGCC My membership no. is _____

I am / am not * a senior Golfer (above 55 years old). My handicap is _____

12:30pm - 1:00pm 1:00 pm - 1:30pm

I enclose a cheque no. _____ made payable to "Singapore Medical Association" of \$160 (non-LNGCC member) / \$100 (LNGCC member) *.

Name: _____ Signature: _____

Address: _____

Tel: _____ Fax / Email: _____

* Delete where applicable.