tubercular chemotherapy, but the duration of follow up and details of recurrence of obstruction are not given.

Ileocaecal tuberculosis should be described as a separate entity from colonic tuberculosis. Anti-tubercular chemotherapy may be used as the primary treatment if a definite histological diagnosis of tuberculosis has been obtained, if there is no suspicion of malignancy, and if there is no intestinal obstruction; in all other cases surgical treatment should be offered.

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Reply

EDITOR,—I thank Dr Kapoor for his comments on our recent publication in which he raises several issues:

1—He contends that ileocaecal tuberculosis should be considered a distinct entity, separate from large or small bowel tuberculosis. He does not, however, provide a rationale for this suggestion.¹ In our report we included caecal lesions (with or without ileal involvement) as colonic lesions because the caecum is anatomically regarded a part of the colon and because the treatment and the response to treatment is the same whether or not the ileum is involved.

2—Caseating granulomas with acid fast bacilli are a histological hallmark of tuberculosis and we agree that in their absence distinction from Crohn's disease can be difficult. In fact, the difficulty in distinguishing Crohn's disease of the colon from tuberculosis of the colon has been repeatedly emphasised in our paper. The granulomas of tuberculosis, however, in contrast to Crohn's disease, tend to be confluent,² have a heterogeneous appearance,³ are composed of larger numbers of multinucleated giant cells,⁴ and are invariably surrounded by inflammatory cells.⁴ As with any disease, a diagnosis must be made based on the history, physical findings, and the results of all the investigations interpreted in the context of the overall clinical situation.

3—Colonic malignancy was considered in 96% of our patients, but this was based exclusively on the colonoscopic appearance. When this was taken together with the rest of the clinical picture and the histology, which showed features suggestive of tuberculosis and no indication whatever of malignancy, we felt justified in initiating treatment for tuberculosis rather than subjecting the patient to a diagnostic laparotomy. While colonic tuberculosis and malignancy of the colon are known to occur in the same patient, this is relatively uncommon, although this possibility should be borne in mind.

4—Patients with intestinal strictures and symptoms of subacute intestinal obstruction have usually been known to respond to anti-tubercular treatment without requiring surgery as part of their treatment.⁵ In general, the

response to chemotherapy, as assessed by a diminution in the intensity of the symptoms and an increased sense of wellbeing is dramatic. We maintain that a trial with antituberculous drugs is indicated in all patients with intestinal tuberculosis except those with complications such as perforation or fistula formation.

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New theories based on inappropriate application of high technology

EDITOR,—The article by Howard *et al* (*Gut* 1991; 32: 1406-11), brought to my attention, has a puzzling conclusion drawn by the authors. Based upon their ultrasound findings, Howard *et al* proposed a new theory that the emptying of the gall bladder after a meal is in three phases. I have read this article with great interest and find that this new theory may have resulted from an inappropriate use of ultrasound for measuring gall bladder emptying.

The measurement of gall bladder volume by a geometric method, called the sum of the cylinder method, was originally described in 1948 by de Silva.¹ The method requires that the gall bladder be a pear shaped organ that can be cut into a series of small cylinders and stacked one above the other. The volume is then computed by summing up the volume of each cylinder. Everson *et al*, using ultrasound, modified de Silva's method slightly by applying the correction factor to account for the change in curvature of the gall bladder.² To be accurate, this method again requires that the

gall bladder be pear shaped and change in the displacement of the longitudinal axis be uniform. Everson *et al*, however, cautioned that the shift in the longitudinal axis may not be uniform in all and that the volume would be an overestimate in the case of long narrow tapering segments at each end of the gall bladder. Also, in situations where the long axis is parallel to but displaced from the central axis, the gall bladder volume will be underestimated in the tapering regions.

The gall bladder at rest has many shapes, often with segmentations and septa. The gall bladder changes its axis and shape during its contraction.³ The mean resting pressure inside the sphincter of oddi is 15 cm of water, the common bile duct 12 cm of water, and the gall bladder 10 cm of water. If the tensed gall bladder does not generate enough pressure inside to overcome sphincter of oddi pressure, it may not empty bile despite appearing small in size. To overcome these disadvantages, we have introduced a count based non-geometric scintigraphic method where the bile emptying measurement is not influenced by the change in shape or the axis of the gall bladder. The bile emptying is measured as ejection fraction. Measurement of the absolute bile volume is not required.⁴

The main portion of the normal gall bladder filling occurs from the absorption of water through the wall and not from frequent emptying and refilling. We studied over 300 normal subjects with technetium-99m HIDA compounds by acquiring the data at a half or one minute interval for 60-120 minutes. A typical gall bladder filling phase is a smooth upgoing curve without any serrations (no emptying or refilling). On rare occasions, a gall bladder may empty spontaneously before the meal. This spontaneous emptying is rare and when it occurs it accounts for less than 5-10% ejection fraction in normal subjects. When the fatty meal is ingested, the gall bladder shows a latent period of 6-16 minutes before it begins to empty bile which is consistent with the known normal release time of endogenous cholecystokinin into circulation. In more than 50 normal subjects, which we studied with a fatty meal, an early dip of the cephalic phase was seen in less than 5%. When the normal gall bladder begins to empty following endogenous cholecystokinin release, it maintains its continuous emptying for 60-120 minutes without

Figure 1: Typical normal gall bladder bile emptying curve following fatty meal. Note a latent period of 16 minutes before bile emptying begins. Once the bile emptying begins it is continuous and sustained with no refilling during the ejection period. (Reproduced with permission from *J Nucl Med* (Ref 5).)

any serrations along the down slope of the emptying curve.'

What Howard *et al* show in figure 1 of their study is an emptying artifact by ultrasound. A change in width and height of the gall bladder after fatty meal is no guarantee that gall bladder bile actually emptied. A tensed gall bladder may fail to empty despite the fact it looks smaller in diameter. In addition there is no way of ensuring that the slice chosen is identical in all of the measurements. The authors have correctly admitted that ultrasound often depends upon patient cooperation and the technologist's skill. A fully filled gall bladder volume is about 40–50 ml. Estimated ultrasound error in measuring the diameter of two large gall bladders was 0.77 mm with a standard deviation of 0.4 mm. What is the error when the volume is between the 0–20 ml range? In a study comparing simultaneous measurement of gall bladder emptying by cholescintigraphy and ultrasound a good correlation was found in the mid range of gall bladder ejection fraction between 20–50%.¹ In five patients, however, where gall bladder ejection fraction was between 0–20% by scintigraphy, the ultrasound overestimated gall bladder ejection fraction as 15–40%. In three of the patients with scintigraphic ejection fraction between 55–85%, the ultrasound underestimated the ejection fraction between 45–65%. Therefore, a geometric method that may be adequate to measure resting gall bladder volume may not be ideal to measure bile emptying especially when volume changes are small.

Figure 1 shows the typical pattern of bile emptying following fatty meal ingestion. Note that after oral ingestion, the gall bladder does not begin to empty for 16 minutes. After 16 minutes, it shows a sustained emptying without any refilling.

It seems more appropriate to combine ultrasound and scintigraphic techniques to assess gall bladder function. Ultrasound is appropriate to measure the resting gall bladder volume and scintigraphy is ideal to measure bile emptying following cholecystokinin or fatty meal stimulation. I suggest the authors use a non-geometric method before proposing a new theory for gall bladder emptying.

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on many points, there remain a few criticisms which we wish to refute. Krishnamurthy's main criticism is that we used ultrasound inappropriately to study gall bladder emptying. He argues that our technique relies on a geometric (sum of cylinders) method and that the changes we saw in gall bladder volume were artefactual.

In our paper, we went to considerable lengths to show that the changes seen in gall bladder volume were not as a result of measurement artefact. Firstly, we showed that the pattern of emptying was altered by changing the stimulus to contraction. Hence, the emptying pattern in response to a cholecystokinin infusion was qualitatively and quantitatively different to that seen in response to a physiological meal stimulus, indicating that the changes were because of an alteration in the behaviour of the gall bladder itself – rather than to errors in measuring gall bladder volume. After a cholecystokinin infusion, the minute-by-minute fluctuations in maximum length and width were increased compared with baseline despite an overall decrease in gall bladder volume. Secondly, by making repeated measurements of the diameters of large 'static' gall bladders in vivo we estimated that the accuracy of measuring gall bladder diameter was 0.77 mm (SD 0.44 mm). This effectively excludes measurement artefact as the explanation for changes in gall bladder volume, especially for small (5–10 ml) gall bladders, which are easier to image than large (40–50 ml) gall bladders. As the volume of a cylinder is proportional to the square of its radius, similar errors in width measurements will have less effect on calculated volume for small compared with large diameter gall bladders.

Dr Krishnamurthy rightly points out that ultrasound is an observer dependent technique requiring each individual gall bladder silhouette to be individually focused. This is an advantage, however, in that it allows the operator to compensate for changes in the position and orientation of the gall bladder as it contracts. We have previously used radionuclide scanning (cholescintigraphy) and ultrasonographic techniques to study gall bladder emptying.¹ Although both methods have their limitations, in our opinion ultrasound is more sensitive than cholescintigraphy, but in the absence of a 'gold standard' discrepancies between the results obtained with the two methods cannot, with validity, be ascribed to artefacts in ultrasonography. Cholescintigraphy, however, cannot be regarded as a 'non-geometric method'. Northfield and colleagues have shown that for accurate counts during cholescintigraphy, a depth correction is required.² Unless anterior and posterior cameras are used, there may be considerable errors in estimating counts over the gall bladder. Furthermore, his assertion that 'measurement of the absolute volume is not required' is based upon in vitro validation studies which may have little relevance to the situation in vivo. Krishnamurthy *et al* validated their method by measuring counts in a balloon filled with water containing ^{99m}Tc of constant specific activity.³ The balloon was moved 0.5 cm, to and fro, 30 times per minute at a constant distance from the gammacamera – hardly a fair representation of the movement of the human gall bladder with respiration.

The important question is whether the gall bladder refills during the postprandial period. This cannot be answered by cholescintigraphy using a single isotopic marker. During cholescintigraphy, the fasting gall bladder fills with isotopically labelled 'hot' bile following an intravenous injection of ^{99m}Tc HIDA. Isotope

counts rise to a maximum over the gall bladder which is then made to contract, after which isotope counts fall progressively (how could they do otherwise?). The so called 'gall bladder emptying' in the figure of Krishnamurthy's letter is, in fact, the change in isotope counts of the area of interest over the gall bladder. It only represents true emptying if there is no gall bladder refilling and the 'specific activity' of gall bladder bile (counts per unit vol of bile) remains constant. Any refilling of the gall bladder with 'cold' bile would lead to a progressive fall in 'specific activity' which would seriously underestimate the true gall bladder emptying rate. Cholescintigraphic 'emptying' curves, therefore, represent not only true emptying but also the displacement of 'washout' of 'hot' gall bladder bile by 'cold' hepatic bile and so are entirely consistent with intermittent filling and emptying of the gall bladder. Northfield and colleagues⁴ labelled hepatic bile with indocyanine green and gall bladder bile with ^{99m}Tc HIDA. Using this dual isotope technique, they measured absolute gall bladder storage and evacuation and also found that gall bladder filling and emptying is intermittent.

Dr Krishnamurthy proposes a combination of ultrasound and scintigraphic techniques to assess gall bladder function. Such a study has recently been reported by Jazrawi *et al*⁵ and showed evidence of postprandial gall bladder refilling as well as emptying in response to a meal. Physiological studies in both humans and animals^{6–8} have shown that gall bladder dynamics are more complex than those suggested by the conventional model. In contrast with Krishnamurthy's findings, but in agreement with evidence from several others, we found a cephalic phase to gall bladder emptying.^{9–11} It is time to reassess the complex neural and humoral factors involved rather than adhere dogmatically to old theories in the face of new evidence.

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Reply

EDITOR, — We thank Dr Krishnamurthy for the interest he has expressed in our paper and for his thoughtful comments. While we agree