Gut, 1966, 7, 387

Gas in gall stones : A rare radiological sign in the acute abdomen

H. R. C. HAY

From the Orpington and Sevenoaks and the Tunbridge Wells Groups of Hospitals

EDITORIAL SYNOPSIS Two cases are described in which films of the abdomen before operation showed triradiate gas shadows considered to be diagnostic of gall stones. The diagnosis was confirmed after operation. The literature describing this sign is briefly reviewed.

As far as can be ascertained, only one case of the 'Mercedes-Benz' sign of gas within gall stones has been described in the British medical literature (Johnstone, 1944). Reference to Johnstone's paper on this rare occurrence is made in 'A textbook of radiology' by Shanks and Kerley in the second but not the third edition. Further reference is made to the phenomenon of gas in gall stones in 'Diseases of the liver and biliary system' by Sheila Sherlock, who quotes two papers published in American journals. In a fairly wide circle of British radiologists and clinicians, I have met only one who has been familiar with the occurrence of gas in gall stones or with the radiological appearance.

On the continent of Europe and in America several papers have been written on this subject, the first as early as 1931 (Breuer, 1931). Such stones are illustrated and described in 'Roentgen-diagnostics', the German textbook of radiology, and it may be that continental radiologists are therefore more aware of the possibility of the phenomenon, and so recognize it when it is apparent in the films. Only about 30 cases have been described in the medical literature.

RADIOLOGICAL DESCRIPTION OF THE SIGN

On rare occasions, gas in the fissures of some mixed gall stones shows up in *x*-ray films as a black shadow of characteristic shape in the gall bladder region. Nearly always it appears as a triradiate or stellate shadow, but occasionally, depending on the direction of the incident beam of *x*-rays in relation to the planes in which the gas lies within the gall stones, one leg of the triradiate shadow may not be shown, so producing a 'sea-gull' effect. In some stones, more than three fissures can be distinguished radiating from the centre of the gall stones. These gas shadows may be seen in *x*-ray films within visible calcified gall stones, thus producing the appearance of a circle containing three more or less equally spaced radii. This appearance accounts for the apt name, the 'Mercedes-Benz' sign (Kommerell and Wolpers, 1938). Less frequently, as in my own cases, the gas shadows may be the only radiological sign of the presence of gall stones not otherwise sufficiently opaque to show in the plain film. As this sign may occur in patients with gall bladders which do not fill with contrast medium, the recognition of the 'Mercedes-Benz' sign may be important as the sole radiological clue to the presence of gall stones. Where gall bladder disease with gall stones may be mimicking other causes of an acute abdomen, the diagnosis is proved beyond doubt if these gas shadows are properly interpreted in the plain films of the abdomen. Air in folds of skin in the umbilicus (Welin, 1938) or gas shadows in faecal material in the bowel have been quoted as simulating the Mercedes-Benz sign, but such shadows can easily be differentiated by further *x*-ray films in different planes. It is generally considered also that the stellate shadow in gall stones is so characteristic as to be unmistakable. Some writers have suggested that once they have become familiar with the *x*-ray appearance and with improved techniques of radiography, many more such stones would be discovered. This has proved true only to a limited extent. Johnstone (1944) stated originally that he had only seen one case in 6,000 cholecystograms and up to October 1963, he had only seen one other case (personal communication). Ortmayer and Connelly (1942) saw one case in 655 consecutive cholecystograms. I have seen it only in the two cases described below.

FIG. 1. *Triradiate gas shadows in the right hypochondrium in a plain film of the abdomen.*

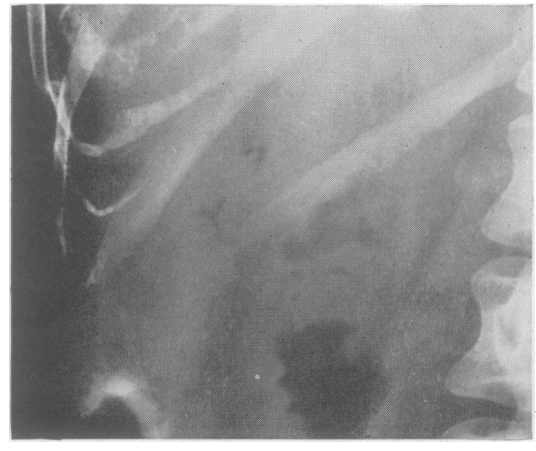

FIG. 2. *The triradiate gas shadows are still visible but have rotated.*

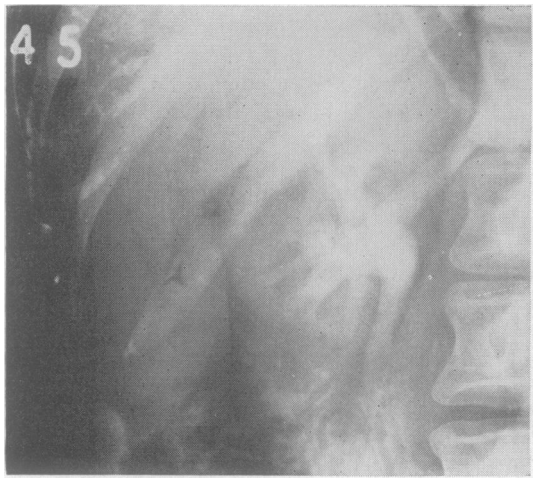

FIG. 3. *Triradiate gas shadows still apparent on intravenous Biligrafin film.*

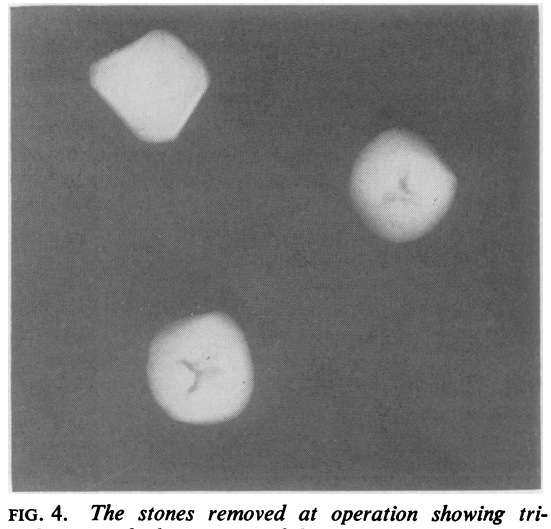

FIG. 4. *The stones removed at operation showing triradiate gas shadows in two of them.*

REPORTS

CASE 1 The patient, a somewhat obese married woman of 43, with no relevant previous medical history, felt tired and off colour on the day before admission and complained of a dull ache in the upper abdomen, worse on the right side. She had no nausea or vomiting. Her urine had been darker for three days and the previous day her faeces were paler than normal. On examination, her tongue was dirty and her breath had an unpleasant foetor. There was no guarding and no rigidity of the abdomen. The presence of a mass was suspected on palpation in the right hypochondrium. The provisional clinical diagnosis was acute cholecystitis.

In the routine plain, supine and erect films of the abdomen, two triradiate gas shadows were visible in the right hypochondrium (Fig. 1). Cholecystography produced no positive gall bladder or duct filling; the triradiate shadows were still apparent, and were seen to have rotated (Fig. 2).

Intravenous Biligrafin films showed filling of the hepatic and common bile ducts, but no filling of the cystic duct or gall bladder. Some of the contrast medium was seen to enter the duodenum, and some was apparent in the pelvis of the right kidney and in the right ureter. The triradiate gas shadows were still apparent (Fig. 3). A firm diagnosis of acute cholecystitis with gall stones was thus established.

At operation the gall bladder was tense, inflamed, and firmly stuck to the liver. Cholecystectomy was performed. On section of the gall bladder the pathologist reported non-specific, long-standing, inflammatory changes with

evidence of adherence of the gall bladder to the liver. There was no evidence of malignancy. The gall bladder contained three mixed gall stones.

The stones were radiographed after removal from the gall bladder and the triradiate sign was seen clearly in two of them (Fig. 4).

So much scepticism greeted the belief that the shadows were caused by gas within the gall stones that the following experiment was conducted. One of the gall stones was placed at the bottom of a glass vessel containing liquid paraffin and broken. Gas bubbles were seen to rise through the oil from the stone. The other two gall stones were subjected to similar treatment, and a cine-film was made in slow motion of the gas escaping from them. The third stone also contained a little gas, presumably in too small a quantity to show up in the films. The fragments of the calculus which emitted the greatest amount of gas were cultured but no growth was recorded.

CASE 2 This patient, a large, married woman of 59, was admitted to hospital complaining of epigastric pain which had lasted for seven days, starting with an attack of colic which had doubled her up. She gave a history of a previous attack 18 months before. Her urine was dark and her stools were pale. She had some guarding and tenderness in the right hypochondrium. A provisional diagnosis of biliary colic was made.

Plain *x*-ray examination of the abdomen showed three very faint gas shadows in the gall bladder region with some calcification a little higher in the abdomen. Tomograms of the right epigastrium were taken and confirmed the presence of Mercedes-Benz shadows within a large distended gall bladder shadow.

At subsequent operation the gall bladder was mobilized. Before the cystic duct was divided, intra-abdominal radiographs were taken of the gall bladder. Although these films were of poor quality, they showed faintly gas within several of the gall stones, thus proving that the gas was present before the atmosphere gained access to the interior of the gall bladder.

Further films were taken of the gall bladder and of the stones after removal, when the gas-containing fissures were seen again (Figs. 5 and 6).

DISCUSSION

Fissures within certain mixed gall stones have long

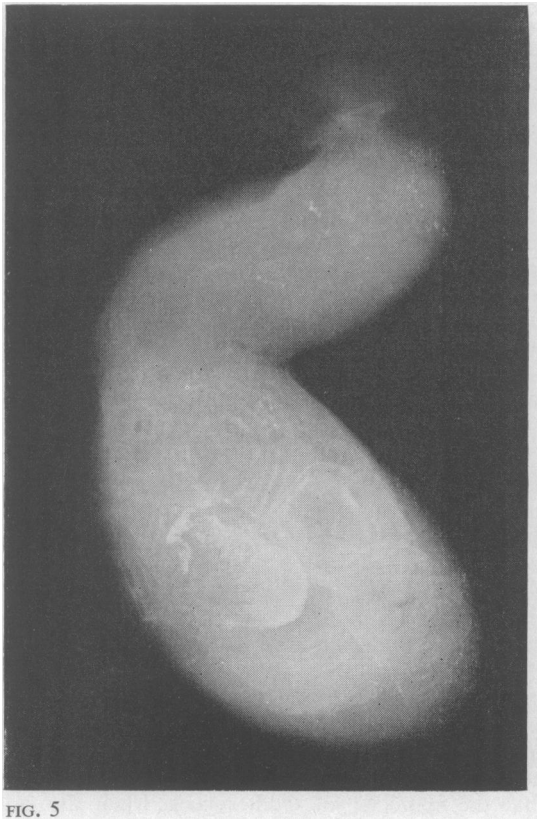

FIG. 5

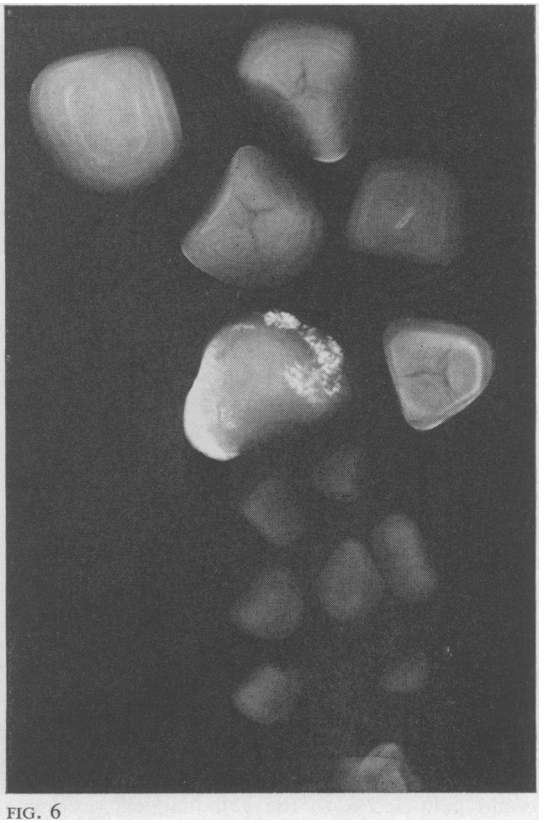

FIG. 6

FIGS. 5 and 6. *Films taken after operation in case 2 showing gas-containing fissures in the stones within the gall bladder (Fig. 5) and in the stones immediately after removal from the gall bladder (Fig. 6).*

been known. Walter is said to have described gall stone fissures in 1796, and Bramson in 1846 discussed possible explanations for their occurrence. Usually, the fissures contain fluid, but they may be filled with cholesterin or have calcium pigment on their walls or filling their interstices. Naunyn, in 1892, measured the amount of fluid in the fissures of gall stones and described its properties, stating that it contained traces of calcium, cholesterin, and sodium chloride. (The fissures are sometimes known as Naunyn's spaces.) Åkerlund (1938), by experiments on the relative densities of different gall stones, and the observation that some would float in bile, while others would not, proved that they contained gas. Kommerell and Wolpers (1938) collected the gas from the fissures of one gall stone and analysed it, the only report of analysis of this gas on record. They found that the gas consisted of 6% to 7% carbon dioxide; 0·5% was oxygen; the rest was a non-inflammable gas, presumably nitrogen.

Nearly every report of gas-containing gall stones is accompanied by a different theory for the presence of the gas and the fissures within the stones. Åkerlund believed that the gas was produced by bacterial action or decomposition inside the stones, while Kommerell and Wolpers thought that all biliary calculi passed through a gas-containing phase.

Torinoumi (1924) thought that the fissures were formed by shrinking of the soft centre of the stone while the fluid in the centre was squeezed out through its rigid outer walls. Hinkel (1950) believes that the fissures are due to the rapid deposit of crystals as gall stones with further solidification of the periphery and contraction and dehydration of the central portion. He says that low pressure voids or fissures within the calculi would favour the inward diffusion of gases from the bile bathing the gall stones into the pre-existing fissures. He also has shown that this happens with freshly removed gall stones which, if left exposed to the atmosphere for some time, develop gas-filled central spaces where before they did not contain gas (Hinkel, 1954). Hinkel also says that fissures are more common in gall stones than was previously believed. In 48 out of 100 consecutive cholecystectomies some of the gall stones removed contained fissures. He has also conducted experiments on the effect of different pressures on dry gall stones containing air to show that in a negative pressure, the air diffuses out of the stone to be replaced by the encircling fluid (Hinkel, 1954). Johnstone postulates that if air could gain access to the gall bladder through an incompetent or abnormal sphincter of Oddi, it is likely that most of the oxygen could be taken up by the bilirubin, leaving a gas similar to that found in the only case so far analysed (Johnstone, 1944).

One other important fact produced by a detailed study of the reported case histories of this phenomenon should be considered. It must be significant that this sign has been seen, according to the cases reported, only in acute cholecystitis. One would expect that if, as Kommerell and Wolpers said, all gall stones pass through a gas-producing phase, many cases of gas-containing gall stones would have been diagnosed in views of the abdomen taken not only for the gall bladder but for the renal tract, the lumbar spine, in diagnostic films of the 'acute abdomen', and in barium studies. According to the literature, and in my own experience, this never happens, except in a few exceptional cases of acute cholecystitis, such as the cases described. There must therefore be a connexion between the appearance of the sign and the occurrence of acute cholecystitis in the presence of mixed gall stones.

As one of the functions of the gall bladder is to concentrate dilute bile by extracting fluid, it would seem highly probable that fluid is also extracted from the centre of the gall stone. This continuing process may well be aided by a degree of osmosis, with attraction of fluid from the gall stone into the surrounding hypertonic bile, and could be more marked in cases of disease of the gall bladder where, either due to blockage of the cystic duct or the neck of the gall bladder by stones or by inflammatory swelling, dilute bile is not permitted to enter the gall bladder in normal quantities. This could conceivable take place over a period of subclinical cholecystitis. With most of the fluid removed from the centre of the gall stone the dry central portion would then crack, as in the mud of a dried up river bed. In the radially formed mixed cholesterin-calcium-pigment gall stones, the cracks would take place along the radial lines, so producing the stellate spaces radiating from the centre of the stone.

Johnstone's belief that the gas within the fissures is proably air with oxygen removed is quite feasible, and his suggestion that air enters the gall bladder through an incompetent or abnormal sphincter of Oddi may well be correct. Since his article it has been shown at the Mayo Clinic (Sedlack, Hodgson, Butt, Stobie, and Judd, 1961) that gas can regurgitate through the sphincter of Oddi, especially in cases of cholecystitis or gall stones. (The common belief that the finding of gas in the biliary tract on *x*-ray examination in the absence of previous operation is always indicative of an internal biliary fistula is not necessarily any longer valid.) It is well known that the sphincter of Oddi relaxes when the gall bladder contracts. Repeated contraction of the gall bladder in an attempt to expel a stone or stones may produce negative pressure in the biliary passages, as

no bile is being expelled (the stone acting as a ball-valve.) With each contraction of the gall bladder the sphincter of Oddi opens and so gas, which is frequently seen in the duodenum during routine barium meal examinations, could enter the biliary passages and eventually the gall bladder. During contraction of the gall bladder contents are under increased positive pressure. The converse of Hinkel's findings in negative pressures may thus occur. Gases from the gall bladder contents around the stones, augmented in concentration by gas which has gained access to the gall bladder as described above, will diffuse through the gall stone walls to occupy the low pressure fissures within the stones.

It is my belief that although one or several of these processes may take place in most patients suffering from cholecystitis with mixed gall stones, it is only rarely that all the processes coincidentally occur in one such patient, thus accounting for the rare incidence of the Mercedes-Benz sign.

REFERENCES

Åkerlund, A. (1938). Über transparente gashaltige Spaltibildungen in Gallensteinen und ihre röntgendiagnostische Bedeutung. *Acta radiol. (Stockh.)*, **19**, 215-229.

Bramson (1846). Ueber Gallensteinbildung. *Z. rat. Med.*, **4**, 193-208.

Breuer, B. (1931). Ueber ein neues Röntgensymptom der Gallensteinkrankheit. *Röntgenpraxis*, **3**, 879-881.

Hinkel, C. L. (1950). Gas-containing biliary calculi. *Amer. J. Roentgenol.*, **64**, 617-623.

—— (1954). Fissures in biliary calculi; further observations. *Ibid.*, **71**, 979-987.

Johnstone, A. S. (1944). Stellate translucencies as a sign of gall-stones. *Brit. J. Radiol.*, **17**, 352-353.

Kommerell, B., and Wolpers, C. (1938). Gashaltige Gallensteine. *Fortschr. Röntgenstr.*, **58**, 156-174.

Naunyn, B. (1892). Klinik der Cholelithiasis. F. C. W. Vogel, Leipzig.

—— (1921). *Die Gallensteine, ihre Entstehung und ihr Bau.* D. Fischer, Jena.

Ortmayer, M., and Connelly, M. (1942). Star-shaped radiolucencies of gallstones: a rare roentgen sign. *Radiology*, **38**, 39-42.

Sedlack, R. E., Hodgson, J. R., Butt, H. R., Stobie, G. H., and Judd, E. S. (1961). Gas in the biliary tract. *Gastroenterology*, **41**, 551-556.

Torinoumi, R. (1924). Über den Bau und die formale Genese, der Gallensteine. *Mitt. Grenzgeb. Med. Chir.*, **37**, 385-436.

Welin, S. (1938). Umbilikus in Röntgenbild. *Röntgenpraxis*, **10**, 421-422.