

kindly prepared the diagrams, and we are pleased to thank Mr. T. W. P. Knowlden, of the Department of Medical Photography, for the photographs.

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A study of the effect of cultural conditions on human fertility in non-industrial or transitional societies, initiated by Unesco, was undertaken by Professor Frank Lorimer, of the American University, in 1951. *Culture and Human Fertility*, price 25s., is the Unesco publication reporting his findings. The first half of the book, by Professor Lorimer himself, is devoted to general theory. In it he states that variations in birth rate "are more powerfully influenced by social and psychological factors" than by conditions of climate or nutrition. All societies, however, were found to practise some method of population control, those in the Pacific being more conscious of the need to adapt numbers to resources than the African. The chief cultural factor influencing fertility seems to be the kinship system: this can be unilateral—that is, either matrilineal or patrilineal—a mixture of both, or, as in Western civilization, have the couple, not the clan, as family nucleus. In both unilateral systems children are welcomed as strengthening the group. Conquest was found to have an adverse effect on the birth rate. The second half of the book, compiled by Professor Lorimer's colleagues, is a record of field-work in demographically interesting areas. The Ashanti were studied as a matrilineal society, the Buganda as a group where tribal authority is losing ground, and Brazil because the population has risen in about a century from 7 to 52 million. Inhabitants were asked about the age of menarche and first marriage, and figures for reproductive rates and infant mortality. Their attitude to pregnancy, extra-marital relations, divorce, and population control was studied.

## DIAGNOSTIC PNEUMOPERITONEUM

BY

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[WITH SPECIAL PLATE]

Although there are a number of references to the usefulness of pneumoperitoneum for visualizing various abdominal organs, the procedure has not come into general diagnostic use, as is clear from the scant mention it receives in standard textbooks of diagnostic radiology. We have recently been using this procedure as an aid to radiological diagnosis of abdominal disease, with particular reference to the gross morbid anatomy of the liver and spleen. Our observations are still limited in number, but we are satisfied that excellent radiographs of these and other abdominal organs can be obtained with the help of this technique, and we believe that it has a useful place among diagnostic methods.

We now present illustrative examples of the findings obtained in a group of patients studied by this method. Although we have so far been particularly interested in the liver and spleen, other abdominal organs can be studied, as will be evident from some of the illustrations we have chosen.

## Methods

## Induction of Pneumoperitoneum

We have induced pneumoperitoneum in one or other of two ways, according to the particular patient.

*In Patients with Ascites.*—In patients with ascites who are subjected to paracentesis, air can immediately be introduced into the peritoneal cavity through the cannula used for draining off the ascitic fluid. This procedure can be carried out with ease. The fact that ascitic fluid is flowing freely through the cannula ensures that its tip is correctly located within the peritoneal cavity. When enough ascitic fluid has been drained off to leave ample space for the air to be introduced, the cannula is connected to an appropriate instrument and air injected. We have used the Maxwell pneumothorax apparatus as being convenient for delivering a known quantity of air, but it is evident that a simple three-way syringe would be adequate. In cases of ascites which come to paracentesis there is usually a large amount of fluid, so that a partial air replacement (1,500–2,000 ml.) can be carried out without causing discomfort, while ensuring that plenty of air is present to facilitate radiological examination. In our opinion the risk of this procedure is negligible. If one listens to the abdomen with a stethoscope while the air is being introduced, the air can be heard bubbling through the ascitic fluid like a burst of machine-gun fire. Alternatively a hand placed on the abdominal wall feels the tactile equivalent of the same phenomenon. These signs confirm that the air is being correctly introduced.

*In Patients without Ascites.*—In these cases a formal induction of pneumoperitoneum must be carried out on the lines now widely used by chest physicians who employ this method as a form of therapy. Good descriptions of the technique are given in most standard textbooks of pulmonary tuberculosis, such as those by Pagel *et al.* (1953) and by Sellors and Livingstone (1952). We have used a Saugmann refill needle inserted after local analgesia into the abdominal cavity at the lateral border of the left rectus abdominis muscle. If the spleen is enlarged the insertion should be made at or below the level of the umbilicus. We have

found that about 1,000 ml. of air is necessary to ensure excellent radiographic views of the liver and spleen, although less complete studies can be made with 500 ml. It has been our practice to induce pneumoperitoneum with about 500 ml. of air on the day before the x-ray examination. On the day of examination the patient is first examined by screening in the erect position to confirm that the air has been correctly introduced, and a refill of another 500 ml. is performed on the x-ray table before proceeding to the full examination described below. In this way the patient is subjected to the minimum amount of interference.

The formal induction of a pneumoperitoneum demands more skill and judgment than the partial air replacement of ascitic fluid, but it is neither difficult nor dangerous if carried out with proper precautions.

#### Radiological Techniques

*Position of Patient.*—The x-ray examination is carried out with the patient on a tilting table. The first step, which is taken whenever the patient's condition permits, consists of a screen examination of the chest and abdomen with the patient erect. With change in the patient's position, free gas in the peritoneal cavity travels readily within that cavity, tending always to collect in the part which is uppermost. Examination with the patient in an upright position therefore shows the free air under the diaphragm—a view familiar in chest radiographs after therapeutic pneumoperitoneum. In the absence of any condition which would cause unusual distribution of the air, the amounts seen on the two sides are approximately equal.

Next the patient is brought into the horizontal prone position by lowering the table while he faces it. Some padding between the chest and thighs may be required for the patient's comfort, particularly if he has ascites. In normal subjects, and also in most cases with disease, in this position the liver and spleen are well outlined by air so that the profile of much of the liver and most of the spleen can be seen. This is the position above all which gives a general view of the size, surface, and relations of these two organs. A single 15 by 12 in. (38 by 30 cm.) film of this view includes the whole of both organs unless there is very great enlargement.

It must be emphasized that the patient is face downwards for this part of the examination. If a patient with pneumoperitoneum is examined in the supine position the air collects immediately under the anterior abdominal wall and fails to outline any of the abdominal viscera. This fact may explain why pneumoperitoneum has been little used in diagnosis.

If either the liver or spleen is poorly outlined by air on the first view obtained in the horizontal prone position, advantage may be taken of the free movement of air to induce more to surround each organ in turn. The patient is turned briefly on to one side (still remaining horizontal) with the poorly outlined organ upwards. On returning the patient to the horizontal prone position the air is found almost entirely on the side which has been uppermost. The vertebral column evidently juts far enough into the abdominal cavity to create separate air compartments when the patient is prone.

Supplementary views may also be taken with the patient lying on one or other side and with the x-ray beam used horizontally.

*Radiographic Technique.*—It is easy to obtain good-quality radiographs of patients with pneumoperitoneum, and a variety of techniques are applicable. However, it may be of value to record some details of the methods we have used.

Radiographs of the patient in the horizontal prone position are taken with an over-couch tube at a distance of 110 cm. A Potter-Bucky diaphragm is usually employed, but pictures of good quality can be obtained without it if the patient is not stout. When a horizontal beam is used, exposures are made with the tube at a distance of 100 cm. and a cassette incorporating a fixed grid.

As an example, in a man of average build the exposure factors are as follows:

Position of Patient	Grid	Distance	kVp	mA secs.	Films
Horizontal prone	Potter-Bucky	110 cm.	86	24	Ilford standard
" " "	None	110 "	70	12	" "
Lateral, with horizontal beam	Stationary	100 "	82	20	" "

## Results

### Normal Appearances

The use of pneumoperitoneum as a therapeutic measure in pulmonary tuberculosis provides a source of material for studying the range of normal appearances of abdominal organs, provided that tuberculous patients in good general condition and without evidence of abdominal disease are selected.

Fig. 1 on the Special Plate shows the radiological appearances of a typical tuberculous subject, whom we regard as "normal" in the present context. This film was taken in the horizontal prone position, which, as mentioned above under "Radiological Techniques," is the one most generally useful for a view of the outlines of the liver and spleen. The right lobe of the liver is well outlined and its characteristic shape and smooth surface are well shown. Overlapping the inner half of the right lobe of the liver, the lateral border of the right kidney shows up sharply. On the left side the spleen is well revealed, both upper and lower poles being clearly outlined. The left kidney is less well seen than the right, and its border is not precisely shown—a finding which is usual. The fundus of the stomach with its small contained air-bubble can be seen overlapping the upper pole of the spleen.

### Alcoholic Cirrhosis

The patient from whom the radiograph shown in Fig. 2 was taken, a woman aged 68, was admitted to the Radcliffe Infirmary on September 24, 1954, suffering from ascites. She had worked as a licensed victualler for many years, but had retired some years ago and was living a quiet life looking after her aged mother. She had a liking for bottled stout, and when feeling depressed sought solace in "one or two gins."

On examination there was found to be gross ascites. A number of spider naevi were present on the skin. The blood count was normal. The urine contained a small amount of protein. The blood urea level was normal (25 mg. per 100 ml.), so also was that of total plasma proteins (6.8 g. per 100 ml.), but the albumin component was low (3 g. per 100 ml.). The plasma bilirubin level was slightly raised (1.9 mg. per 100 ml.), but flocculation tests of liver function (thymol turbidity and colloidal gold) were negative.

A paracentesis abdominis was performed with removal of 4 litres of ascitic fluid which was clear, straw-coloured, and lymphocytic. Paracentesis was carried out twice more during the next ten days, and on the last occasion 2,000 ml. of air was introduced through the paracentesis cannula in the manner described earlier and the patient examined radiologically. In view of the large amounts of ascitic fluid withdrawn, this amount of air was not judged to be excessive.

The radiograph (Plate, Fig. 2) shows a liver greatly reduced in size. The whole surface of the organ is closely studded with small nodules, giving rise to the classical appearance of "hobnail liver" familiar in post-mortem studies of these subjects. The spleen does not appear to be significantly enlarged. Some barium is present in the stomach and small intestine, but is not relevant to the present findings.

### Biliary Cirrhosis

The radiograph in Fig. 3 is from a woman of 73 admitted to the Cowley Road Hospital. In 1944 her gall-bladder was removed because of cholelithiasis, and two years later her common bile duct had been explored. Subsequently biliary cirrhosis developed. In 1949 she again had a laparotomy for exploration of the common bile duct, but no gall-

stones were found. Recently she had suffered from liver failure, but at the time of our examination she was relatively well. There was no jaundice and no ascites, and her general state of nutrition was good. The spleen was much enlarged.

Formal induction of a pneumoperitoneum was carried out, and the radiograph shows the appearance of the liver and spleen. The liver is very small. No air would travel between it and the diaphragm, which we take to be a sign of extensive adhesions between the two. The inferior border of the liver appears coarsely irregular; we cannot decide whether this is due to extensive scarring of the liver or to adhesions. The spleen is greatly enlarged, with a smooth surface.

#### Peritoneal Metastases of Neoplasm

A man aged 46 was admitted to the Radcliffe Infirmary in May, 1954, because of haematemesis following a one-year history of dyspepsia. After medical treatment he made an uneventful recovery from the haematemesis, but radiological examination revealed a carcinoma of the stomach. At operation a large fungating tumour was found and a number of lymph nodes showed evidence of malignant involvement. A palliative partial gastrectomy was performed. Thereafter he was well until November, 1954, when bronchitis with vomiting developed and he was readmitted to the Radcliffe Infirmary suffering from ascites. The ascitic fluid was partially replaced by air and he was examined radiologically. The liver and spleen appeared to be normal, but there was evidence of multiple peritoneal metastases. In Fig. 4 we have selected a film which shows some of these located immediately above the spleen; other views not reproduced here showed that these deposits were below the diaphragm. Both leaves of the diaphragm are thickened and their inferior surfaces appear irregular in places.

The patient later died and was examined post mortem, when extensive peritoneal deposits were found. The spleen was normal, as also was the liver apart from one solitary nodule, 1 cm. in diameter, probably a secondary deposit

#### Retroperitoneal Tumour Displacing the Spleen

A man aged 49 was transferred to the Radcliffe Infirmary from another hospital in December, 1954, with a six-months history of pyrexia and pain in the left side of the abdomen. In the previous September a chest radiograph had shown a left pleural effusion and aspiration had yielded a pleomorphic fluid with no malignant cells seen. In November, 1954, a mass was felt below the left costal margin which was thought to be the spleen. Hodgkin's disease was regarded as a likely diagnosis.

There was disagreement on whether the palpable mass was a spleen or not. Formal induction of a pneumoperitoneum was carried out and some of the subsequent radiological findings are shown on the Plate (Fig. 5). The liver appears normal. The lower border of the mass is clearly the spleen. No air would travel above this organ. We could not decide why the air failed to pass around the spleen to appear beneath the left diaphragm. At operation a large retroperitoneal tumour, probably a reticulosarcoma, was found in the left upper abdomen, pushing down the spleen and itself occupying the subdiaphragmatic space.

#### Pleural Effusion Mimicking High Left Diaphragm

The patient with whom Fig. 6 on the Special Plate is concerned was a young man of 23 with a long history of lymphatic derangement. Some puffiness of the face was noticed at 2½ years of age. Later he developed gross swelling of the legs and scrotum with the characteristics of a lymphatic oedema. However, he was generally well and worked as a builder's labourer. On seeking to change his occupation he was subjected to x-ray examination of the chest, and this showed an opacity in the left thorax which required investigation. There were physical signs suggesting a pleural effusion, and paracentesis thoracis yielded a chylous fluid. However, the appearance of the chest radiographs at that time (Fig. 6a) gave rise to doubt whether a pleural effusion was the whole explanation, particularly as some clinicians thought that they could palpate the spleen. Ex-

tensive x-ray investigations with the help of pneumothorax failed to settle the issue, and most of the radiologists concerned were of the opinion that the left diaphragm was raised. Formal induction of a pneumoperitoneum permitted an exact radiological assessment. Fig. 6b shows a low left diaphragm with a small, normal spleen lying beneath it.

#### Discussion

For about 40 years pneumoperitoneum has been used as an aid to radiological diagnosis, but it has not become generally accepted in Britain and we have been unable to find any British reference to its systematic use for the study of diseases of the liver and spleen. It was only after we had discovered the importance of the horizontal prone position when taking radiographs of the liver and spleen that we found this position already advocated in an article from Algeria by Aubry and others (1954). We therefore claim no originality in the radiological method, but are sufficiently convinced of its usefulness to recommend its more widespread adoption.

No diagnostic method should be recommended without some appraisal of the risks involved. In cases in which there is ascites we believe that the additional risk of introducing some air into the peritoneal cavity during paracentesis abdominis is negligible so long as attention is paid to the physical signs described in the relevant section above. The liver and spleen are frequently abnormal in patients with ascites; peritoneal deposits may be revealed by pneumoperitoneum, as exemplified in Fig. 4; and neoplasms of other abdominal organs, such as the ovaries, may likewise be demonstrated. For these reasons we now believe that any patient who suffers from ascites the underlying cause of which is not apparent should be studied by this method. With respect to a formal induction of pneumoperitoneum in patients without ascites, the method has been so extensively used as a therapy for pulmonary tuberculosis that fairly precise estimates of its dangers are available. Although a large number of different complications have been described (Stein, 1951) they occur but seldom, and serious complications are rare. In most patients the induction is painless and does not give rise to subsequent discomfort. In some patients, however, the procedure is followed by a tight feeling in the upper abdomen or pain in the shoulder tip. These symptoms can be relieved by keeping the patient supine for a few hours. The serious complications are air embolism, surgical emphysema of the anterior abdominal wall, mediastinal emphysema, spontaneous pneumothorax, and perforation of a viscus. Correct attention to the technique of induction will minimize the risk of these. Fatal complications are rare. For example, Simmonds (1946) reported only one death (due to air embolism) in the course of more than 13,000 air injections; and Trimble and others (1948) treated 407 tuberculous patients with pneumoperitoneum with only one death (also from air embolism) due to therapy.

Naturally some clinical judgment should be brought to bear on the selection of patients for diagnostic pneumoperitoneum. For example, it would be manifestly unwise to practise this procedure on a patient with congestive heart failure who has no respiratory reserve. However, provided such patients are excluded, we do not think that diagnostic pneumoperitoneum should be any more hazardous than when it is used for therapy. The risk involved seems to be low enough to permit our advocating its use in cases presenting diagnostic problems which pneumoperitoneum may help to solve.

### Summary

Pneumoperitoneum is a diagnostic procedure which enables useful radiographic studies to be made of various abdominal organs. In particular, the liver and spleen can be clearly demonstrated by examining the patient in the horizontal prone position.

In patients suffering from ascites, pneumoperitoneum can be induced with great ease and negligible risk by performing partial air replacement at the time of paracentesis abdominis. This should be done in all patients with ascites in whom the underlying diagnosis is in doubt.

In patients without ascites, formal induction of a pneumoperitoneum is an easy procedure the risk of which is sufficiently low to justify its use as a diagnostic method.

Results with this method are presented with special reference to the liver and spleen. Its more widespread adoption is recommended.

We are grateful to Dr. R. R. Tilleard-Cole for clinical assistance, and are much indebted to Miss M. Bell, who carried out most of the radiography. We wish to thank our colleagues in the United Oxford Hospitals for referring patients to us.

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## DUODENAL ULCER TREATED BY VAGOTOMY AND GASTRO- ENTEROSTOMY

### RESULTS OF 100 CONSECUTIVE CASES

BY

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Many observers have recorded their results following vagotomy and gastro-enterostomy for duodenal ulceration, and experiences have varied. The purpose of this report is to add to these experiences the results obtained from a series of 100 consecutive cases of duodenal ulcer similarly treated. None of the patients were selected for this operation as opposed to any other, the only criterion for inclusion in the series being the need for surgical as opposed to medical treatment. In addition, between 1946 and 1948 one of us performed this operation on 45 occasions and it was the apparently satisfactory initial follow-up of these patients which prompted us to undertake the present series. However, a further incomplete check of these patients reveals that at least 9 (20%) have required further gastric surgery.

#### Material

Of the 100 patients 78 were men and 22 women. The youngest was 25, the oldest 77, with an average age of 45 years. The operations were performed by members of the

surgical unit of St. Mary's Hospital, and these followed a standard pattern. This consisted of confirmation of the diagnosis by laparotomy, and a posterior gastro-enterostomy combined with resection of at least 1 in. (2.5 cm.) of the vagi and their branches after mobilizing and withdrawing into the abdomen the supradiaphragmatic portion of the oesophagus.

There was one almost immediate post-operative death associated with collapse and peripheral circulatory failure, probably due to a coronary thrombosis. The remaining 99 patients recovered and in due course were discharged to attend the follow-up clinic. Ten patients (10%) have defied all efforts to trace them recently enough for their inclusion in an evaluation of the results. Nevertheless an analysis of their progress, so far as it is known, is given later.

Eighty-nine patients (89%) have been followed up for varying periods, the average length of follow-up at the time of submitting this report being 29 months. Such a short follow-up probably fails to represent the final picture, but, as will be seen, the results are of such a nature as to warrant an early report. These patients were seen at increasingly long intervals unless their progress was unsatisfactory, when they were seen more frequently. Attention was paid to the patients' subjective state of health, their ability to undertake their normal work being considered important. Examination was primarily clinical, barium-meal studies and gastroscopy being undertaken only when the clinical findings warranted them. Fractional test meals and insulin test meals were not undertaken as a routine, because of the invalidity of achlorhydric results due to biliary regurgitation after a gastro-enterostomy.

#### Results

The results in these 89 patients have been classified thus: (1) Excellent; (2) good; (3) persistent post-operative syndromes with or without dyspepsia; (4) persistent dyspepsia alone, with no proved recurrence of ulceration; (5) recurrence of peptic ulceration; and (6) miscellaneous.

1. *Excellent*.—These results occurred in patients who subjectively and objectively were completely free of any dyspepsia or post-vagotomy and gastro-enterostomy syndromes from the immediate post-operative period. There were 33 such patients (37.1%). One died from cerebral haemorrhage two years after operation. Up to the time of his death he had had no recurrence of his symptoms, and at necropsy there was no evidence of further peptic ulceration.

2. *Good*.—Into this category fell patients who post-operatively had temporary disturbances, but which have now completely disappeared. There were nine such cases (10.1%). Six patients had temporary post-vagotomy and gastro-enterostomy syndromes, one patient had temporary dyspepsia, and two patients had both temporary post-operative syndromes and dyspepsia.

3. *Persistent Post-vagotomy and Gastro-enterostomy Syndromes With or Without Dyspepsia*.—Thirty patients (33.7%) still had persistent disturbances dating from the operation. Five of them also had dyspepsia, in one of which it was temporary and in four permanent. Whether associated with dyspepsia or not, 38 patients (42.7%) had post-vagotomy and gastro-enterostomy disturbances, of which 8 (9%) were temporary and 30 (33.7%) permanent. In two of the permanent cases some of the symptoms had disappeared, suggesting that ultimately they may fall into the temporary category.

#### Classification According to Severity

	Temporary	Permanent
Severe ..	—	6
Moderate ..	2	11
Mild ..	6	13

Of those suffering from permanent severe syndromes two felt worse for having the operation, two had to abandon their original jobs and undertake light work, and one has had to absent himself from work for a day or two every few weeks.

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FIG. 1.—Normal appearances.

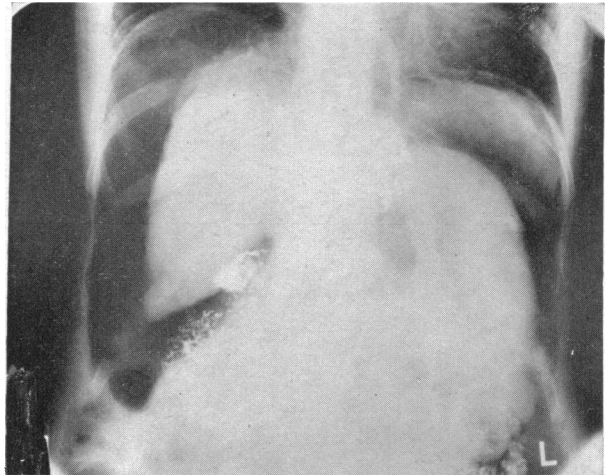


FIG. 2.—Alcoholic cirrhosis. Liver small with "hobnail" surface. Spleen probably normal.

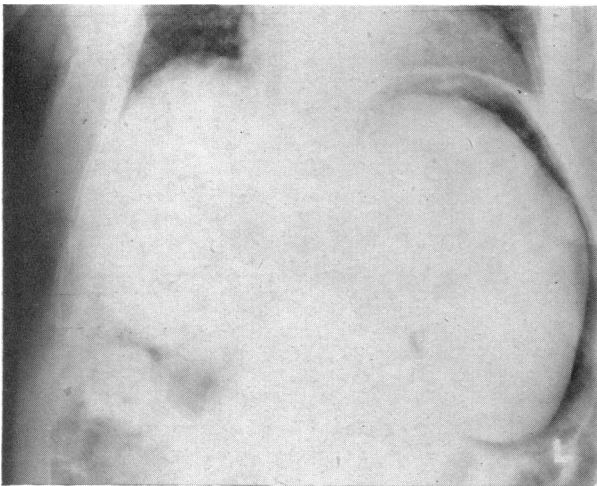


FIG. 3.—Biliary cirrhosis. Liver small and adherent to diaphragm. Spleen much enlarged.

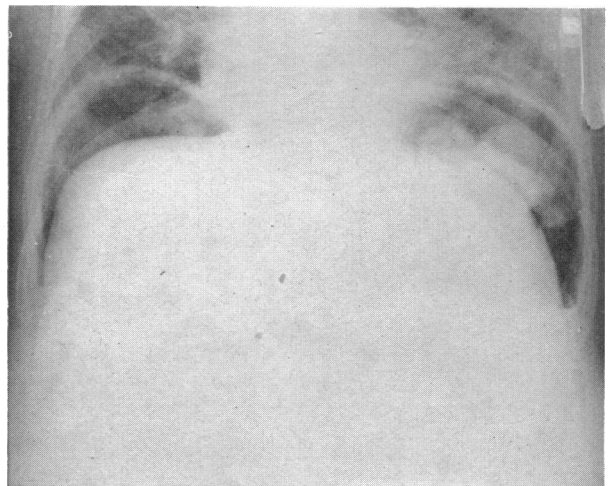


FIG. 4.—Secondary neoplastic deposits below the left diaphragm. Liver and spleen normal.

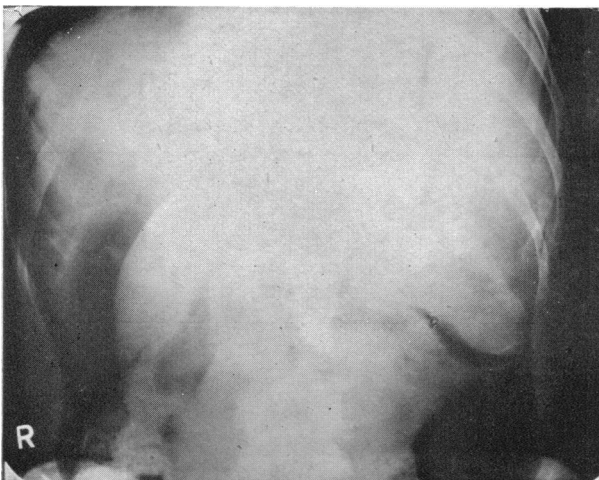


FIG. 5.—Retroperitoneal neoplasm with displacement of spleen. Liver normal. Lower pole of spleen set low. No air above the spleen, because of a tumour subsequently found at operation.

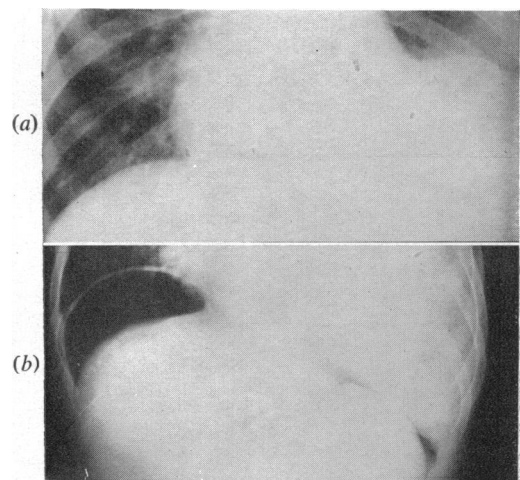


FIG. 6.—Pleural effusion mimicking high left diaphragm. (a) Plain x-ray film. (b) Film after pneumoperitoneum showing diaphragm to be low.