were included in the analysis. Elwood *et al.* found that women with a haemoglobin below 10.5 g/100 ml had a cholesterol value that on the average was 30 mg/100 ml lower than in women with normal haemoglobin values. By using the regression equation in Table III for women aged 20-54 it can be calculated that a lowering of the haemoglobin from a normal of 14 g/100 ml to a low normal of 11 g would mean a decrease in the cholesterol value of 18 mg/100 ml, a figure of the same order of magnitude as that of Elwood *et al.* The same correlation was found for serum triglyceride values. The relation was also found in men both for cholesterol and for triglyceride, a finding not previously reported.

The variations in serum lipid values with the haemoglobin levels previously seen in anaemia have not been explained. They may, of course, be coincidental and largely independent of each other. As pointed out by Elwood *et al.*, 1970, possibly the lower haemoglobin levels in women might be connected with lower serum lipid values, and this could partly explain the lower incidence of ischaemic heart disease in premenopausal women and of people in developing countries.

Possibly part of the relation between cholesterol and haemoglobin values in women, now extended to include also triglycerides, and men may be explained by changes in plasma volume. If we assume that the blood volume remains unchanged as the haemoglobin in women decreases from 14g to 11 g/100 ml, as quoted above, the packed cell volume would decrease from 40 to 32% and thus the plasma volume would increase from 60 to 68%. If in women the total plasma pool of cholesterol and triglycerides were unchanged and the concentration of cholesterol was 250 mg/100 ml and triglycerides of 1.10 mmol/l. with a packed cell volume of 40%, the values would decrease to 220 mg/100 ml and 0.97 mmol/l. if the packed cell volume went down to 32%. Thus a change in plasma volume could be predicted to lower serum cholesterol and triglyceride values by

30 mg/100 ml and 0.13 mmol/l. respectively. From the equations in Table III the corresponding figures can be calculated to be 18 mg/100 ml for cholesterol and 0.13 mmol/l. for triglycerides.

Assuming unchanged total plasma pools corresponding figures for men would be by calculation 30 mg/100 ml and 0.19 mmol/l. and by the regression equation (Table III) 14 mg/100 ml and 0.37 mmol/l. Though many assumptions are involved and there are great standard errors in the equations the values obtained by calculation, assuming unchanged plasma pools, are much the same as those obtained by applying the regression equation. Hence simple changes in plasma volume may in part account for the positive correlation between haemoglobin and plasma lipids. This new hypothesis is further substantiated by the findings of Rifkind and Gale (1967), who showed that the decrease in serum cholesterol and phospholipids was not due to a specific lowering of any one of the serum lipoprotein families but was caused by a proportionate fall in all three of the major lipoprotein families, a finding which is indeed compatible with a plasma volume dependent effect.

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Serum Enzyme Levels in Diagnosis of Postoperative Myocardial Infarction

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Summary

The levels of creatine kinase, hydroxybutyric dehydrogenase, and aspartate transaminase have been serially measured in the serum of patients undergoing surgery. Serum enzyme levels often rose to a range commonly found after myocardial infarction but fell to normal within 5-10 days. Raised serum enzyme levels have no diagnostic significance in a case of postoperative chest pain until after the fifth postoperative day, but may be significant thereafter.

Introduction

The differential diagnosis of chest pain in patients who have recently undergone chest or abdominal surgery is apt to be difficult; pain due to inflammatory lesions of the lungs or pleura, to surgical trauma, or to myocardial or pulmonary infarction may all produce similar symptoms. Raised levels of certain

serum enzymes occurs in some cases of pulmonary infarction (Henley, Schmidt, and Schmidt, 1966; Mullan, 1969) and in 90-97% of cases of myocardial infarction (Agress, 1959; Henley *et al.*, 1966). These changes may precede any abnormality in the electrocardiogram by up to several days (Wood, 1968; Mullan, 1969), and serum enzyme estimations are therefore very valuable in the early diagnosis of myocardial infarction. Operative injury, however, may also result in the release of these same enzymes from the damaged tissues (especially skeletal muscle) into the circulation (Lawrence and Schulkins, 1956; Watanabe, Kaltus, and Semenson, 1957; Henley *et al.*, 1966). Hence in the early postoperative period raised levels of serum enzymes are not necessarily significant in the diagnosis of myocardial infarction.

In order to establish the extent and duration of changes in serum enzyme levels due to operative injury the levels of aspartate transaminase, hydroxybutyric dehydrogenase, and creatine kinase were serially measured in the serum of patients undergoing a variety of surgical procedures.

Patients and Methods

Routine "cold" surgical patients undergoing thoracic or abdominal operations were studied. Aspartate transaminase, hydroxybutyric dehydrogenase, and creatine kinase were esti-

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mated preoperatively and postoperatively at 24 hours and 3, 5, 7, and 10 days. Electrocardiography was performed preoperatively and on the seventh postoperative day. Patients were excluded from the study if the preoperative enzymes were raised (one case), if the electrocardiogram was abnormal preoperatively or postoperatively (one case), or if there was any clinical evidence of deep-vein thrombosis or myocardial or pulmonary infarction (one case). The patients were otherwise unselected.

Fourteen patients aged 29 to 78 were included in the study; 4 underwent thoracotomy, 3 cholecystectomy, 3 vagotomy and pyloroplasty, 2 partial gastrectomy, 1 colectomy, and 1 suprapubic prostatectomy.

The aspartate transaminase and hydroxybutyric dehydrogenase levels were estimated using spectrophotometric methods (Rosalki and Wilkinson, 1960; Bergmeyer and Bernt, 1965; Laudahn, Hartmann, Rosenfeld, Weyer, and Muth, 1970) and creatine kinase levels by a colorimetric method (Hughes, 1962). By these methods the normal range for aspartate transaminase is 4-15 IU/l., for hydroxybutyric dehydrogenase 50-150 IU/l., and for creatine kinase 4-60 IU/l.

Results

The results are summarized in Figs. 1, 2, and 3, and in the Table. In 10 patients there was a rise of all three enzymes, maximum levels being attained on the first or third postoperative

Range of Enzyme Levels and Peak Rise in Activity after Operation. Results expressed in IU/l.

	Aspartate Transaminase	Hydroxybutyric Dehydrogenase	Creatine Kinase
Preoperative	6-14	50-150	15-59
Postoperative:			
24 hours	7-62	60-336	89-550
3 days	6-56	90-406	43-535
5 days	9-44	71-145	27-330
7 days	10-23	86-155	27-67
10 days	13-20	95-150	18-35

Normal ranges are given in the text.

day in most cases, thereafter falling again to normal levels within a few days. The range of enzyme levels postoperatively was very large, and in four patients (two vagotomy and pyloroplasty, one cholecystectomy, and one prostatectomy) there was only a slight rise in creatine kinase, while the aspartate transaminase and hydroxybutyric dehydrogenase remained within normal limits throughout the period of study. In general, the highest postoperative rises in enzyme levels were seen in patients who had the most extensive operative trauma (thoracotomy patients).

FIG. 1 Normal limits of aspartate transaminase levels and mean levels (± 1 S.D.) before and after surgery. FIG. 2—Normal limits of hydroxybutyric dehydrogenase levels and mean levels (± 1 S.D.) before and after surgery. FIG. 3—Normal limits of creatine kinase levels and mean levels (± 1 S.D.) before and after surgery.

Discussion

These results show that there is a rise and subsequent fall of these three serum enzymes in most cases after surgery. Our findings are consistent with those of Watanabe *et al.* (1957) and Lawrence and Schulkins (1956), who found rises in transaminases after major operations. Schlieff and Kamm (1957) observed rises in transaminase and lactic dehydrogenase after heart surgery, and equated this finding with the enzyme changes occurring after myocardial infarction. Raised transaminase levels have also been found within minutes of experimental burns in rats (Spector and Pauli, 1963).

On the other hand some workers found raised transaminase levels only after certain operations, including biliary tree surgery (Person and Judge, 1958; Rehn, Koehnlein, Graner, and Zeller, 1960), liver biopsy or manipulation, extensive trauma to skeletal muscle, large postoperative abscess or haematoma, pulmonary resection, and possibly prolonged anaesthesia (Person and Judge, 1958), though Lawrence and Schulkins (1956) found no difference when either general or spinal anaesthesia was used. Rehn *et al.* (1960) found no rise in enzyme levels after a variety of other operations including splenectomy, prostatectomy, herniorrhaphy, appendectomy, and renal surgery. Henley *et al.* (1966) stated that enzyme changes postoperatively were, "absent or slight," and Person and Judge (1958) felt that in most cases the enzyme changes were too small to cause diagnostic confusion.

Our results showed that in some cases postoperative enzyme levels were within the range often found after myocardial infarction (Elliott and Wilkinson, 1962; Henley *et al.*, 1966), though the average time course differed slightly from that after myocardial infarction. In every case in the present series the hydroxybutyric dehydrogenase had returned to normal within five days of operation, the creatine kinase within seven days in 13 of the 14 patients, and by 10 days all the aspartate transaminase levels were below 20 IU/l., and most were within the normal range. Raised levels of the relevant serum enzymes within these postoperative periods must therefore be interpreted with great caution. After the fifth postoperative day, however, raised serum enzyme levels become progressively more useful in the diagnosis of chest pain.

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Diagnosis of Ruptured Aneurysm of Abdominal Aorta

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Summary

A retrospective analysis of 44 cases of ruptured aneurysm of the abdominal aorta showed that only 14 were correctly diagnosed when admitted to hospital. The diagnosis was established in the ward after admission in 14 cases, in the operating theatre in one, and at necropsy in 15. The various clinical presentations are described, since early diagnosis and operation are essential to save life. Awareness of the condition and a careful examination of the abdomen are most important in making the diagnosis.

Introduction

Death is inevitable after rupture of an abdominal aortic aneurysm unless an operation is performed, and even then half of the patients die (Alpert *et al.*, 1970). The correct diagnosis is often overlooked. Textbooks of medicine and surgery describe the common presentation with abdominal pain, shock, and a pulsatile abdominal mass but give few details of other presentations. Immediate diagnosis and early treatment are essential to save life, and in order to clarify the diagnostic problems we analysed the records of 44 patients with ruptured aneurysm of the abdominal aorta, 41 of whom had been admitted to King's College Hospital since 1958 and the other three were seen at the Brook Hospital in August 1970. Patients with ruptured dissecting or iliac aneurysms were excluded from the review. Seven of the patients were referred from another hospital and only one was moribund on arrival.

Clinical Findings

The 44 patients were aged 55 to 84 years (mean 70) and only five were women. The clinical findings at the time of admission are summarized in Table I. Seven of the patients were known to have an aneurysm.

Pain was the most constant feature and was absent in only three patients. In 14 patients the agonizing pain associated with rupture had been preceded by mild backache for up to three weeks. The pain was usually localized to the centre or lower abdomen, though on occasions it closely mimicked ureteric colic or radiated into the thighs. The pain was localized to the left and right sides equally often.

Thirteen patients presented with collapse ranging from a simple faint to a temporary cardiac arrest. These episodes were usually associated with severe pain and the patients often had few other symptoms. Vomiting was seldom severe, though three patients had a haematemesis and one was admitted on account of rectal bleeding. Half of the patients

were shocked. In five the tachycardia was masked by slow atrial fibrillation. The systolic blood pressure on admission varied. In 15 patients it was below 80 mm Hg and in 10 above 150 mm Hg.

An abdominal aneurysm was felt in 20 patients but in six of them it was thought to be intact. An additional mass was felt in 16 patients and in nine it was observed to pulsate. In 12 cases the mass was distant from the aorta, and its significance was often overlooked. Some abdominal tenderness was invariable but pronounced muscle guarding occurred in nine patients. In no case were the bowel sounds noted as absent. Abnormalities of the femoral pulses were found in eight patients and absent lower limb reflexes were found in five. Only one patient had an ischaemic leg.

The correct diagnosis was made at the time of admission in only 14 patients. In another 14 it was made after their arrival in the ward, and in one it was made during laparotomy for suspected appendicitis. In the remaining 15 patients the diagnosis was made after death. The main cause for the diagnostic delay in 30 (68%) of the patients was lack of awareness of the variable clinical picture of ruptured aortic aneurysms (see Table II).

Only four of the patients left hospital alive. Of the 40 who died 14 were operated on and 26 were not. In four of the 26 there was no time for operation, four were unfit for operation, four were "inoperable," and in 14 the diagnosis was not

TABLE I—Symptoms and Signs in 44 Patients with Ruptured Aneurysm of the Abdominal Aorta

	No. of Patients		No. of Patients
Pain:		Sweating	25
Abdominal	24	Pulse 100	22
Back	21	Systolic blood pressure:	
Lower limb	10	<80 mm Hg	15
Loin	5	>150 mm Hg	10
Ureteric colic	5	Palpable aneurysm	20
Absent	3	Other mass	16
Collapse	13	Abdominal tenderness	40
Vomiting	13	Abdominal guarding	9
Haematemesis	3	Abnormal femoral pulses	8
Known aneurysm	7	Abnormal leg reflexes	5
Pallor	35		

TABLE II—Clinical Presentations of Ruptured Abdominal Aortic Aneurysm and Diagnostic Errors in 44 Cases

Presentation	No.	No. Incorrectly Diagnosed	Diagnostic Errors
Classical	18	4	Aneurysm diagnosed but no rupture
Mass	14	11	Gastric cancer (2), splenomegaly, hepatomegaly, renal mass (2), mesenteric cyst, hydronephrosis, urinary bladder (2), diverticular mass
"Acute abdomen"	26	11	Perforated duodenal ulcer, pancreatitis (2), cholecystitis (2), appendicitis (2), diverticulitis (3), mesenteric thrombosis
Collapse	16	9	Coronary thrombosis (3), cerebral embolus (2), bronchopneumonia (2), pulmonary oedema, pulmonary embolus
Urological	15	10	Loin mass (3), ureteric colic (5), urinary retention (2)
Gastrointestinal bleeding	4	4	Gastric erosions, duodenal ulcer (2), mesenteric thrombosis
Vascular	5	5	Dissecting aneurysm (2), mesenteric thrombosis (2), iliac artery thrombosis
Neurological	2	2	Cerebral embolus (2)

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