CLINICAL PROGRESS

Re-opening the Case of the Abdominal Aortic Aneurysm

By Irving S. Wright, M.D., Enrique Urdaneta, M.D., and Barbara Wright, B.S.

UNTIL recent years, the problem of the abdominal aortic aneurysm* was of academic interest only. The diagnosis once established by physical examination or laparotomy was accepted with a reaction of fatalism toward the future. The rate of progress was uncertain but the life span was shortened and in some cases death occurred within a few weeks or months. On the other hand, for reasons unknown, there were patients who survived for five years or longer. There was no known treatment. It was recognized that while most thoracic aneurysms were syphilitic in origin, the greater percentage of abdominal aneurysms were on the basis of atherosclerosis. The majority of these involve the lower abdominal aorta, which is used in this paper to signify the portion below the renal arteries. This interesting phenomenon was clearly shown in Blakemore's† series of 365 cases of aortic aneurysm. Of the 192 syphilitic aneurysms, 182 involved the thoracic aorta and only 10 involved the abdominal aorta; whereas of the 143 arteriosclerotic aneurysms, 114 involved the abdominal aorta and only 29 involved the thoracic segment. Of 30 miscellaneous types including mycotic, traumatic and unclassified, 15 were thoracic and 13 abdominal in location, 2 were unclassified. The reason for this anatomic predilection has never been completely clear, but the explanation of Blake-

more is worthy of careful consideration. He suggested that the explanation of the development of aneurysm resulting from atherosclerosis of the lower abdominal aorta was due to several factors:

1. Widespread atherosclerosis tends to involve the entire aorta, including the lower abdominal segment.

2. The pressure of pulse waves striking the aortic bifurcation and the iliac arteries tends to produce a reverse wave that meets the oncoming next pulse wave. This results in a hammerhead of pressure with a sideways thrust and stress on the aortic wall, which is not well supported by sheathing or surrounding tissues at this point.

3. This stress may be aggravated by the fact that the aorta is fixed at the diaphragm and by the iliac fascia. Between these two fixed points, the aorta tends to elongate with atherosclerosis. It usually deviates to the left. This bending tube tends with further strain to dilate into a fusiform aneurysm. This lack of fixation and the deviation forward also explain why erosion of the spine and radiculitis are rare in abdominal aneurysms as compared with thoracic aneurysms.

While these may be logical explanations for the location of atherosclerotic aneurysms in the abdominal aorta, they fail to explain the predilection of the spirochete for the thoracic aorta. This has been held by some to be related to the arrangements of the lymphatic system, but this must be regarded as speculation rather than fact.

With the development of surgical procedures that render the abdominal aortic aneurysm subject to attack, it seems justified to attempt a critical evaluation of the current situation.

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* This report does not include a consideration of dissecting aneurysm.
The results of surgery are striking, often spectacular, but not universally successful. Why?

This presentation attempts to examine the questions dealing with prognosis, symptoms, signs and other means of diagnosis, selection of cases, indications and contraindications, effects of location, extent and type of aneurysm, preoperative and postoperative care and surgical technics (briefly).

Prognosis. To justify this relatively radical surgery it is necessary to establish that the outlook for the patient is poor without surgical intervention and that such an approach offers a reasonable chance for improving the outlook. At present, the view is held by some surgeons working in this field that most patients have a life span of less than two years after discovery of the aneurysm. They reason, therefore, that operation is imperative and should be done with minimum loss of time, citing examples of patients who have died from rupture of their aneurysm before they could be operated upon. On the other hand, there are many internists and general practitioners who take a rather casual attitude toward these aneurysms after their discovery. They cite patients who have lived for many years with an aneurysm without much progression or rupture. It is probable that, to date, most of the series of cases reported by surgeons fail to represent the true picture in this regard, since patients who are having pain, increase in the size of the mass or other signs associated with expansion of the aneurysm are especially likely to gravitate toward the surgeon, as compared to those who are symptom free.

One of the most revealing articles in this regard is that of Estes reporting the experience of the Mayo Clinic. The prognosis of 102 cases is seen in table 1. Approximately 58 per cent survived 2 years, only 19 per cent survived 5 years, and 10 per cent survived 8 years. It should be remembered, however, that the mean average of this group of patients was 65 years at the time of diagnosis, so that the expectant mortality during the subsequent years would naturally be high. Estes reported that the mortality of patients with abdominal aneurysm was consistently higher than that found in comparable groups without such aneurysms.

<table>
<thead>
<tr>
<th>Years</th>
<th>Total</th>
<th>Patients traced</th>
<th>Survival beyond period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>1</td>
<td>102</td>
<td>91</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>84</td>
<td>74</td>
<td>43</td>
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<td>3</td>
<td>74</td>
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<td>4</td>
<td>62</td>
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<td>5</td>
<td>46</td>
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<td>20</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>8</td>
<td>0</td>
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</table>

In his series, the cause of death in 49 of the 64 known dead was as follows: 31 (63.3 per cent) died from rupture of the aneurysm; 18 (36 per cent) died from other causes.

In our series of 68 patients who were investigated for life expectancy, the findings are given in table 2. This shows that 39.7 per cent lived less than 1 year after the diagnosis was made. Only 20, or 29.4 per cent, were alive at the end of 2 years. Eight, or 11.8 per cent, lived 4 years, and less than 5 per cent lived 5 years. A very few of these patients may have died of causes other than their aneurysms.

These figures indicate a prognosis comparable to many forms of cancer, and the condition must be recognized as a malignant one. On the basis of these experiences, the use of a fairly radical approach seems justified, since no form of conservative therapy exerts any effect on the course of this condition. The results of surgery are discussed later.

Present Series. We have analyzed the data from 107 cases of abdominal aortic aneurysm seen at the New York Hospital during the 10-
TABLE 3.—Ratio of Recognized Abdominal Aortic Aneurysms to Total Admissions to The New York Hospital

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of admissions</th>
<th>No. of abdominal aortic aneurysms</th>
<th>Per cent of abdominal aortic aneurysms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945</td>
<td>17,589</td>
<td>6</td>
<td>0.03</td>
</tr>
<tr>
<td>1946</td>
<td>19,079</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>1947</td>
<td>20,098</td>
<td>3</td>
<td>0.01</td>
</tr>
<tr>
<td>1948</td>
<td>20,457</td>
<td>5</td>
<td>0.02</td>
</tr>
<tr>
<td>1949</td>
<td>20,914</td>
<td>7</td>
<td>0.03</td>
</tr>
<tr>
<td>1950</td>
<td>21,944</td>
<td>14</td>
<td>0.07</td>
</tr>
<tr>
<td>1951</td>
<td>21,249</td>
<td>12</td>
<td>0.06</td>
</tr>
<tr>
<td>1952</td>
<td>21,500</td>
<td>13</td>
<td>0.06</td>
</tr>
<tr>
<td>1953</td>
<td>22,644</td>
<td>21</td>
<td>0.09</td>
</tr>
<tr>
<td>1954</td>
<td>22,824</td>
<td>15</td>
<td>0.07</td>
</tr>
<tr>
<td>1955</td>
<td></td>
<td>7 (incomplete)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>208,298</td>
<td>107</td>
<td>0.05</td>
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TABLE 4.—Age Incidence

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of cases</th>
</tr>
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<tbody>
<tr>
<td>40-49</td>
<td>4</td>
</tr>
<tr>
<td>50-59</td>
<td>24</td>
</tr>
<tr>
<td>60-69</td>
<td>38</td>
</tr>
<tr>
<td>70-79</td>
<td>34</td>
</tr>
<tr>
<td>80-89</td>
<td>7</td>
</tr>
<tr>
<td>Average age</td>
<td>66.0</td>
</tr>
</tbody>
</table>

year period between 1945 and 1955 (fig. 1 and table 3). For age incidence see table 4.

Signs and Symptoms. Although signs and symptoms of this condition have been previously listed, it is believed that analyzing them in greater detail may focus attention on more precise and earlier diagnoses in the future. In addition, the present rarity of syphilis as an associated factor and other considerations may alter the findings. For example, this series was practically entirely of white patients, there being only four Negroes. There were 89 males and 18 females. In Lord’s series\textsuperscript{3} 22 out of 23 were males. Dr. Jere Lord has kindly consented to allow us to study an additional series of 23 patients, not admitted to The New York Hospital. In some respects this group is of particular interest, since patients referred to a surgeon may differ from those in a mixed hospital population.

The diagnoses in our series were made or confirmed as follows: clinically, 63; x-ray study, 48; laparotomy, 16; post mortem, 24. The diagnosis was first made at laparotomy in 5 patients and first made at postmortem examination in 20 patients.

Pain. Pain was a major complaint, but 34 patients did not suffer from it. Of the others, 27 had severe pain, 7 described it as crampy, 13 complained of rather diffuse discomfort. Many had pain or other symptoms involving more than one area. In Dr. Lord’s cases, 21 out of 23 suffered from pain. This is to be expected in a selected group such as those referred to a surgeon. The distribution of pain is shown in table 5. In some cases, the pain as well as other symptoms ascribed to the aneurysm may, in fact, have been due to some other disease, so that the symptoms herein listed as due to the aneurysm are approximate rather than absolute. Symptoms are listed in table 6. Seventeen patients remained asymptomatic. In Blakeimore’s series,\textsuperscript{1} 33.6 per cent and in Estes’

TABLE 5.—Distribution of Pain

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Abdominal</td>
<td>54</td>
</tr>
<tr>
<td>Low back</td>
<td>34</td>
</tr>
<tr>
<td>Legs</td>
<td>13</td>
</tr>
<tr>
<td>Chest</td>
<td>12</td>
</tr>
<tr>
<td>Groin</td>
<td>7</td>
</tr>
</tbody>
</table>

TABLE 6.—Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constipation</td>
<td>17</td>
</tr>
<tr>
<td>Pain</td>
<td>73</td>
</tr>
<tr>
<td>Anorexia</td>
<td>13</td>
</tr>
<tr>
<td>Vomiting</td>
<td>13</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>9</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>8</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>8</td>
</tr>
<tr>
<td>Throbbing sensation</td>
<td>6</td>
</tr>
<tr>
<td>Unconsciousness</td>
<td>4</td>
</tr>
</tbody>
</table>
series, 30.4 per cent were asymptomatic on admission.

Physical Signs. The commonest physical sign was a mass, which was noted in 65 patients. For the various locations of this mass, see table 7. In 59 cases, the masses were pulsatile. Some of these masses could be felt laterally as well as in the midline. The actual location of the aneurysm was found to be below the renal arteries in 58 cases and above the renal arteries in 12. In 15 cases, the aneurysm involved the bifurcation and proximal iliac arteries. Nineteen patients had 31 other aneurysms in various other arteries. Five had additional aneurysms involving the thoracic aorta. None of our patients had evidence of the rare complication of associated aneurysm of the coronary arteries reported by Rukstisiat.4 His patient died from a rupture of an aneurysm of the abdominal aorta and was found to have six aneurysms of the right coronary artery associated with marked atherosclerosis. An aneurysm of the left common iliac artery was also present, but that is not unusual. Manohar5 reported an aneurysm of the left coronary artery complicating an abdominal aneurysm which, however, was primarily of the celiac axis, involving the celiac branches above and the superior mesenteric artery below. Death occurred as a result of a rupture between the aorta and the aneurysm. In this case, the postmortem studies supposedly established the etiology as syphilis. Physical signs of our patients are listed in table 8.

Roentgenographic Studies. In 16 cases the diagnosis was made in the course of routine abdominal x-ray examinations. In 10 cases it was made in the course of intravenous pyelogram studies. In 23 cases it was more completely delineated by aortograms. It should be mentioned that, at times, anteroposterior and lateral films of the abdomen may show the outline of the dilated aorta clearly delineated by the calcific deposits, whereas the aortogram shows only a smooth tube about the size of the aorta and without evidence of any disease. This was very definite in the case of patient G.M. (fig. 2). It was due to the formation of a firm thrombotic lining of the aneurysmal sac. In such cases the aortogram fails to be helpful, while the diagnosis may be clear on physical examination and routine x-ray studies. Aortograms are not always uneventful. There have been cases of hypersensitivity reactions to the injected substance and of local hemorrhage, although these are few.

The following case illustrates another type of problem.

M.B., a 64 year old, unmarried woman noticed cramps in the abdomen, especially in the lower quadrants, seven years prior to admission. She then had bloody diarrhea with 4 to 5 stools in a period of 4 hours. This was accompanied by anorexia, nausea and slight vomiting. X-ray films showed diverticulitis with fever and leukocytosis. Six years prior to admission, she had developed gnawing pain in the epigastrium that did not radiate at first but kept recurring on walking. It was unrelated to meals and relieved by the ingestion of hot water or by pressure. A pulsating mass was felt, and the diagnosis of abdominal aneurysm was made. The pain disappeared for a year, after which it recurred with the same characteristics. This kept recurring. The patient was able to continue her work as a domestic servant. Six months prior to admission the patient had an increase of symptoms with increasing anorexia.
and weight loss of 10 pounds. Four months prior to admission she noticed a “pounding” sensation in the epigastrium. This progressed, becoming more severe, especially on the day before admission, when she developed marked nausea and nocturia (30 times). This patient developed the signs and symptoms of myocardial infarction, immediately following an abdominal aortogram that revealed an aortic aneurysm. She died, and autopsy showed atherosclerotic coronary occlusion with apical myocardial infarction. A second infarction, 3 by 4 cm. in size, was present in the septum. The coronary arteries were severely atherosclerotic with narrowing of the lumina to pinpoint size at numerous points. A thrombus occluded the left circumflex branch. There were aneurysms of the abdominal aorta and of the iliac arteries. An aneurysm 12 cm. in length and 5 cm. in diameter was present in the aorta between the superior mesenteric artery and the bifurcation. There were smaller aneurysms of each common iliac artery and one of each internal iliac (hypogastric) artery.

A typical case history illustrating many of the above points may be found in that of patient G.M.I., a 54 year old man who first developed evidence of arteriosclerosis obliterans in the right leg in 1946. A lumbar sympathectomy was performed in an Army hospital. This resulted in warming up the foot but no improvement in the claudication distance of one and a half to two blocks. X-ray films taken at that time revealed calcification of the walls of the aorta and the major vessels of both legs. No evidence of an aneurysm was noted then, nor until 1953. Meanwhile, on a conservative regimen including abstinence from tobacco, he did very well, increasing his walking distance up to one-half mile. He was carefully followed and frequently examined in detail during the intervening years. No abdominal mass was felt. In April 1953, the patient noticed the onset of recurrent night pain in the left side of the abdomen. After two weeks, a severe pain developed in the same area and, shortly after, examination revealed a peach-sized pulsating mass. X-ray examination revealed calcific deposits

![Diagram](https://example.com/diagram.png)

**Fig. 2.** Patient G. M., tracings made of calcific outlines of aorta showing evidence of increase in size of the abdominal aneurysm between Nov. 10, 1953 and June 9, 1955 (lateral view).
in the wall of the aorta outlining a dilatation mostly to the left, extending from the interspace between the second and third lumbar vertebrae to the interspace between the fourth and fifth. This was observed during the next two years. There were very few symptoms, but in June 1955 physical and x-ray examinations showed definite enlargement of the aneurysm (fig. 2). The aortogram was of little value, since it merely showed a tubular lumen of about the normal size, the remainder of the aneurysm being filled with clot (fig. 3). In this case, as in many others, the physical examination and the plain film of the abdomen were more useful than the aortogram. A transplant was decided upon, and this was performed by Dr. Edward Keefer. Aneurysms were also found in each of the iliac arteries, about 2.5 cm. in diameter and about 2 cm. below the bifurcation of the aorta. The immediate postoperative condition was satisfactory but the following day he developed respiratory distress and cyanosis. His condition deteriorated and, despite transfusions, Levo- phed and oxygen, he died that afternoon.

Autopsy Findings: Arteriosclerotic cardiovascular disease with resected aneurysm of the abdominal aorta, severe coronary sclerosis and diffuse myocardial fibrosis. (Patient G.M.) There was extensive atheromatosis of the upper abdominal and thoracic aorta, with some calcification and ulceration of atheromatous plaques. The lower abdominal aorta was resected and a graft inserted. The proximal anastomosis of the arterial graft was just caudal to the renal arteries, and the distal common iliac anastomoses were 3 cm. from the bifurcation of the aorta. There was only a small amount of clotted blood around the suture lines, which appeared to be intact. The lumen of the graft was patent. All the coronary arteries were calcified and their lumina narrowed by as much as 95 per cent. There was hemorrhage within one of the plaques in the right coronary artery. There were several foci of fibrosis within the myocardium; the largest measured 8 mm. in diameter and was in the interventricular septum.

The gallbladder was absent. The common duct was dilated and measured 1.8 cm. in circumference. A pyramidal stone, 5 mm. in diameter, lay in an out-pouching of the duct, 1 cm. from the ampulla of Vater. There was granularity of the ductal mucosa. The biliary system was patent.

Two ulcers, one adjacent to the other, were present in the left lateral wall of the duodenum 3 cm. from the pylorus. Each measured 6 mm. in diameter and 3 mm. in depth. Some of the abdominal complaints may have been due to these accessory findings.

Laboratory Findings. The most commonly encountered laboratory findings are presented in table 9. Evidence of renal disease was usually found associated with aneurysms above or involving the renal arteries. Aneurysms may dissect the walls of the renal arteries and produce renal calculi, uremia and hypertension. No such cases were found in the present series from which dissecting aneurysms were excluded.

![Aortogram that failed to reveal actual outline of aneurysm because of laminated thrombus lining the lumen. The black line indicates the true wall as indicated by calcific deposits that were clearly seen but too fine to show on this reproduction. It shows the aneurysm in the right iliac artery, but fails to reveal the corresponding one in the left iliac artery.](image-url)
Additional Pathologic Conditions. Eighty-three of these patients had definite evidence of atherosclerosis elsewhere in their arterial system. Seventy-two had cardiovascular disease, which was predominantly atherosclerotic, with or without hypertension. Fifty-four had high blood pressure, using the upper standards of normal as 150 maximum systolic and 90 maximum diastolic. Only four had diabetes mellitus. Twenty-two suffered from gastrointestinal disease, including 7 with cancer, 5 with peptic ulcers and 3 with inflammatory reactions, such as gastritis, 4 with diverticulitis and 2 with gallbladder disease. These conditions frequently produced confusing symptomatology. Twenty-two had genitourinary complaints including 7 with cancer of the bladder, 5 with nephrosclerosis, 3 with uremia, 2 with cancer of the prostate, 3 with renal infarcts and a variety of less significant conditions. Nineteen had evidence of pulmonary conditions; 10 of these had emphysema; the others varied greatly but included 4 with cancer of the lungs. Seven had evidence of neurologic conditions, including 5 with cerebral vascular accidents and 3 with cerebral vascular disease without strokes.

Only four of these patients had serologic or other evidence of syphilis, and in only one instance was it believed that the aneurysm might have a syphilitic component. Even in this case, syphilis was believed to be of doubtful importance in reference to the development of the aneurysm. This presents further evidence of the striking trend of the decreasing significance of syphilis as a factor in the development of aortic aneurysm. The picture is not quite so clear-cut, however, in reference to abdominal aneurysm as it might appear at first glance. Although it has long been recognized, as mentioned above, that thoracic aneurysms were predominantly syphilitic, while abdominal aneurysms were less likely to be, early papers still list syphilis as a cause or contributing factor in from 25 to 75 per cent of cases of abdominal aneurysms. It is doubtful that this represents the actual facts. Careful study of these papers indicates that in many instances the mere finding of positive serologic or historical evidence of syphilis, but without histologic evidence at the site of the aneurysm, led to the conclusion that any aortic aneurysm was wholly or partly due to syphilis. In the light of present knowledge, that assumption was unjustified and led to invalid conclusions. This was especially aggravated by the fact that some of these reports came from the South, where the percentage of Negroes in the cases studied was high and where syphilis was extremely common among Negroes at that time. On the basis of pathologic findings, it appears that there has been some decrease in the number of syphilitic abdominal aneurysms but that this is much less significant than might be concluded from a casual study of the figures alone. For a review of this trend and the problems of analysis, as outlined above, the reader is referred to the papers of Kampmeier,7 Hubeney and Pollack,8 Scott,9 Blakemore,10 Estes2 and Goldowsky.11

Mycotic Aneurysms. Mycotic aneurysms of the abdominal aorta are very rare and none were encountered in the present series. It is probable that in the future they will be even rarer because of the widespread use of antibiotics. Mitchell and Clairveaux12 reported a case with rupture of a mycotic aneurysm of the abdominal aorta following pneumococcus endocarditis and they list five cases from the literature which were secondary to bacterial endocarditis. The youngest patient on record to our knowledge was a child 7 years and 9 months old, reported by Baginsky in 1908.13 This patient had a streptococcal endocarditis and an aneurysm of a subclavian artery as well as the abdominal aorta.

Wilcox and Fisher14 described a case of particular interest. A 54 year old woman developed subacute bacterial endocarditis (Streptococcus viridans). Emboli occluded the femoral arteries of both legs. Following heavy penicillin therapy her temperature returned to normal, clubbing of her fingers disappeared and the spleen was no longer palpable. The patient nevertheless did not feel well. She had pains in the legs, hips and lower abdomen and a persistent pulse, about 120 per minute. The blood cultures were persistently negative. Thirty-four days after she became afebrile, a pulsatile mass appeared below the umbilicus. Twenty days later she died of a rupture of this aneurysm in a matter
of minutes. At autopsy, bacteria were found in the wall of the aneurysm, but none could be found in the blood or the heart valves.

Rupture of Aneurysms of the Abdominal Aorta. Rupture is the most dreaded terminal event in the history of these aneurysms. Seventeen aneurysms in the present series ruptured. In nine of these, the aneurysm had been diagnosed before the rupture in periods ranging from several months to two years. In seven patients the diagnosis of aneurysm was made only when it ruptured. In none of these cases was an increase in the size of the mass noted before it ruptured. In one case, however, there was a sudden appearance of a nonpulsating mass on the day of the rupture. All 17 of these patients died as a result of the rupture. This has been the usual experience. However, with the advent of newer surgical techniques, we should re-examine the possibilities of this complication. Logically, the best method is prevention by excision and replacement of the aneurysmal segment prior to the rupture. Even symptomless aneurysms may rupture, so that they do not guarantee safety; but frequently the patient is not seen until the aortic wall is perforating and rupture is imminent or taking place. It is common belief that it is then too late to operate, but from now on it appears that, in the best of surgical hands, an increasing number will be successfully operated upon.

The series reported by Goldowsky is of interest in this regard. He reported 15 cases of spontaneous, abdominal aortic perforation verified by postmortem examinations. He emphasized that, contrary to common belief, rupture of the abdominal aorta is not a cause of sudden death. The patients in his series survived from 5 hours to 27 days. Twelve patients survived more than 24 hours, 8 patients more than 5 days. It appears, therefore, that in each patient in this entire series there was time for surgical intervention. In our series, the survival period was shorter, being from 1 to 3 days, but in some there was ample time for surgical intervention. Time is only one factor but has been generally thought to be too brief for such an approach. Goldowsky’s cases were reported in 1952, and most of them died prior to the era of aortic grafts; but they are instructive. In 10 patients, the aneurysms were below the renal arteries and therefore might have been considered amenable to surgery. Arteriosclerosis was marked and thought to be the etiologic factor in each case. No syphilis was found. This was in contrast to the findings of Nixon, who in 1911 reviewed the literature and found 223 cases of abdominal aneurysms of which 152 ruptured. He reported that the “majority” had syphilis. As pointed out above, however, that does not prove that syphilis was an etiologic factor in these aneurysms, unless proved pathologically in each case. DeBakey has made notable strides in surgery for ruptured aneurysms, having been able to operate successfully on 73 per cent of his cases.

Type of Aneurysm. In 58 cases the type of aneurysm was satisfactorily classified at autopsy or laparotomy. In 32 patients, the aneurysm was fusiform in type. In 26 patients, the aneurysm was saccular. This was a high percentage of saccular abdominal aortic aneurysms, compared with most series. Dissecting aneurysms usually start in the thoracic area and the dissection proceeds distally into the abdominal area. It may also dissect toward the heart. Dissecting aneurysms were not included in this study, except for a single one that was confined to the abdominal aorta.

Treatment. A total of 85 of these patients received no specific treatment for their aneurysm. This reflects the fact that most of them were seen in an era when surgical treatment was not available. Figure 4 shows the increase in interest in the surgical approach in the past four years, as indicated by the request for grafts from the Blood Vessel Bank.

The Surgical Approach. If surgery is to be elected it must be justified by evidence that the risk is less than the prognosis without surgery. Fifteen of these patients had resection and graft. Nine of these were successful. Failures were due to rupture of the anastomosis in 2 cases, uremia in 2 cases, leakage of the aneurysm in 1 case, and rupture preoperatively in 1 case. Four cases were wrapped with plastic material. The results were successful in three cases. One died, 1 day postoperatively, of pulmonary edema and shock.

Two patients were treated by the Blakemore
wiring procedure with the following results: 1 patient is still alive after 5 years, 1 died 3 days postoperatively and 1 patient had his aorta ligated below the renal arteries, but developed gangrene of the legs and died.

In Dr. Jere Lord's series subjected to surgery, 11 were resected and grafted, of which 5 have been successful; 5 were treated by wrapping, of whom 2 are alive (1 month and three and one-half years postoperatively). Two were injected with sodium dicetylphosphate, one is alive.

Dr. S. W. Moore has operated on 11 patients for abdominal aortic aneurysm and 9 have been successful, with satisfactory postoperative courses up to two years. One patient died in the hospital. He had a history of two myocardial infarctions. He was operated on for a ruptured abdominal aneurysm and after this died of thrombosis of the left common iliac artery with rupture. The other death occurred 5 weeks after operation from an infection of the anastomosis of the right common iliac artery with rupture and hemorrhage. One living patient is seriously ill with heart failure.

In recent years this problem has been vigorously attacked by numerous surgeons of note. The introduction of fine wire into the aneurysmal sac to encourage reinforced clot formation with electric stimulation was developed and studied with great care by Blakemore and his co-workers. The wrapping of the outer walls of aneurysms by cellophane and other fibroplastic-stimulating materials has been carried out by numerous surgeons. While the results in certain specific patients have apparently been encouraging, many of them have died at the time of operation or soon after, so that the proof that the prognosis is on the average better for the patient is difficult to establish and in our opinion lacking. The over-all operative mortality in Blakemore's series of 1954 was 37.2 per cent. Of these, rupture was the cause in 19.1 per cent (20 cases). Nine of these showed evidence of rupture before operation, 3 ruptured at operation and 8 ruptured postoperatively; 18.1 per cent died of other causes, including heart failure and thrombosis. If wrapping is attempted, Blackmore prefers to use a strong plastic cloth such as Nylor or Vinyon N.

**Types of Operation**

1. Aortic occlusions proximal to aneurysm (no longer used).
2. Thrombo-endoaortarectomy and wrapping (no longer used).
3. The production of thrombosis within the aneurysm by means of wiring, with or without endothermy (no longer used).
4. Partial or complete external reinforcement or wrapping (used by some surgeons when graft is not feasible because of patient's condition or technical difficulty).
5. Resection and replacement (favored today).
   a. Homograft.
   b. Prosthesis of Dacron, Orlon, Vinyon N or other plastic (in the developmental phase).

Not all of the patients who have had the wiring procedure have done poorly. For example, patient R.H., age 77, was operated on in 1950 for an abdominal aneurysm, at which time silver wire was introduced. In 1951 a second operation was performed and more silver wire inserted. Both operations were performed by Dr. Blakemore. In 1955 the patient was alive and active and was admitted to The New York Hospital for a ureteral calculus, which was passed. Incidentally, he has also survived a myocardial infarction, with development of atrial fibrillation, left bundle branch block and periodic cardiac decompensation.

While a few surgeons still use wrapping in some cases where resection seems impractical,
ABDOMINAL AORTIC ANEURYSM

the interest today is definitely in the direction of resection of the aneurysm, with the substitution of a graft of either homologous aorta or a prosthesis of plastic material such as Vinyon N or Orlon. This type of procedure is still fraught with considerable risk but the great progress of the past five years indicates more successful use in the future. Saccular aneurysms are frequently attached by a pedicle that may permit lateral clamping and suture. This procedure often produces excellent results and has been reported by many surgeons including Dubost and Dubost,17 Bahnson18 and DeBakey, Cooley and Creech.16, 19 The sac should be removed, if possible. If a whole sac is left in place, the danger of infection is considerable. If a portion of the sac is adherent to a vital area such as the inferior vena cava, it may be necessary to leave it in place. This has been successful in many cases.

So far as we can determine, the first successful homologous graft to replace a fusiform aneurysm of a human aorta was performed by Dubost on March 29, 1951.20 The graft was functioning and in good condition when reported three years later.17 This was a graft of considerable size, extending from the level of the renal arteries to include the upper portion of the right common iliac artery and was attached to the left common iliac artery. Dubost and Dubost17 emphasized that the aorta near an aneurysm is often thickened, friable and indurated with calcareous patches or medial necrosis. It is, therefore, easily cut by sutures, producing secondary ruptures. They mentioned ruptures that occurred on the twenty-ninth day and six months after resection. They also point out that if syphilis is present, antibiotic treatment should certainly be given prior to surgery. While we must agree to this, the effect on the outcome of any specific operation may be doubtful, especially in the case of abdominal aneurysms, which are so rarely syphilitic today.

The number of homografts performed since that of Dubost cannot be determined because they are now being undertaken in many areas of the world today. The degree of over-all success is also difficult to determine; but on the basis of our knowledge from wide travel and work in various countries, it can be stated that to this date there is a great variation in the results. This is to be expected with any new, highly technical procedure and is based on lack of experience with this operation, unsatisfactory preparation and preservation of the grafts and lack of criteria of indications and contraindications for this type of procedure, as well as all the usual problems of surgery in the elderly patient with widespread arteriosclerosis and, frequently, other diseases. Outstanding reports have come from the clinics of Bahnson18 and DeBakey.16, 19 In 1954, Bahnson18 reported 14 patients in whom he had performed aortic homografts and 11 were alive and well (1 patient required amputation of a leg). In 1955, DeBakey and his associates reported that 49 abdominal aneurysms had been resected and grafted. Of those who recovered, 36 were reported to be in excellent condition, while none were in poor condition. Thirteen died, 7 of coronary disease, 4 died early of renal failure, 2 died later of unspecified causes. In all but six cases the aneurysm involved the bifurcation, which had to be resected. The death rate of the operation was 16 per cent below 60 years of age and 32 per cent above 60 years of age. In 13 patients, Orlon-cloth prostheses had been used to replace aortic bifurcations with satisfactory results. DeBakey presented additional figures before the Annual Session of the American Heart Association in October 1955 (table 10).

One of the technical steps of major concern has been the prolonged occlusion of the aorta with the secondary ischemia of the tissues of the legs. We have observed several examples of failure of adequate restoration of circulation after this procedure with loss of one or both legs. This has occurred in patients who had

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demonstrated marked evidence of occlusive arteriosclerotic disease prior to operation. Therefore, proper account of this risk should be undertaken in the preoperative study of the patient. DeBakey and Cooley state that for aneurysms below the renal arteries, arrest of circulation with an aortic clamp for 120 minutes has not produced residual ischemic changes. They have used two procedures to reduce this risk: (1) lumbar sympathectomy as part of their operation and (2) injection of 10 mg. of heparin into the aneurysm, just before occluding the aorta, to retard thrombophile effects of retarded blood flow in the distal vascular bed. It is our belief that this dosage is probably on the low side for this purpose, but we recognize the undesirability of producing too generalized a bleeding tendency during such an operation. They claim that most patients actually had improved circulation to their lower extremities after the operation. These results certainly justify much wider use of this technic by properly equipped surgical teams.

For successful, widespread use of homografts, a highly efficient Blood Vessel Bank with a large source of suitable grafts is a requisite. This paper does not attempt to discuss the technic or functioning of such a bank. It appears that the demand may well outstrip the supply, even in large cities, especially since in many cases bifurcations are needed. In smaller communities and for emergencies, prostheses of synthetic material should be available, if practical. Their use has been explored by numerous workers, notably Blakemore and DeBakey. Blakemore has used 37 denier, 144 by 90 strands per square inch of Vinyon X cloth. In dogs sacrificed 19 to 153 days postoperatively, he found all prostheses to be encased in fibrous tissue 1 to 5 mm. in thickness. The inner surface was covered with a thin, translucent film, consistent with multiple layers of flattened cells and collagen fibers with fibroblasts growing through the interstices of the cloth. Of the first four cases in man, using this material, 1 died in 5 days from uremia and 1 died of hemorrhage from rupture of a thinned posterior wall proximal to the line of suture. Two patients did well and were discharged with good pulsations in the arteries of the feet. As mentioned above, DeBakey reported 13 such cases, using Orlon and Nylon, with good results. While at present homografts are favored, the use of such prostheses should be developed. They offer the great practical advantages of ease of preparation and preservation, and they can be woven or cut to fit almost any foreseeable demand in terms of vessel length or arrangement. Careful preoperative studies make a satisfactory analysis possible in most cases. However, the decision whether or not to attempt a surgical procedure has sometimes been difficult without laparotomy.

E.M., a 54 year old man, a patient of Dr. Edward Keefer, exemplifies this point. Six months prior to admission he developed a watery diarrhea that lasted two weeks. There was no bleeding. Following this, he noticed a sharp, aching left abdominal pain. There were occasional episodes of nausea and vomiting. There was a 12 pound weight loss believed to be related to diminished intake.

On physical examination a firm, pulsating mass, measuring 4 by 3.5 cm., could be felt in the left upper quadrant, just to the left of the umbilicus. Systolic and diastolic murmurs could be heard.

Roentgenographic studies showed the calcific outlines of an abdominal aortic aneurysm. Intravenous pyelograms showed a nonfunctioning left kidney, the outline of which could not be clearly seen.

An aortogram revealed a somewhat enlarged thoracic aorta, an abdominal aneurysm extending from just below the origin of the superior mesenteric artery, and partially involving this area and the celiac axis, to below the bifurcation of the aorta. The left renal artery was apparently occluded in the wall of the aneurysm, and the left kidney was nonfunctioning. The right renal artery was not visualized and arose also from the aneurysm wall. There was, however, excellent visualization of a right double kidney. The aneurysmal sac consisted mainly of a large clot with a relatively narrow central channel. It was concluded by Dr. Keefer
that this aneurysm was inoperable in every respect.

The symptoms were progressive, and the patient was later explored in the hope that something might be accomplished to help him; but this was not possible. He was alive two years later. He had gained 40 pounds and had no complaints but the large pulsating mass. This exemplifies the difficulties of prognostication, since his condition has continued to be unexpectedly good.

Another patient of Dr. Keefer’s is of interest because of the very long operative procedure.

J.P., male, age 65, considered himself in good health until three weeks prior to admission, at which time he noted a mild, crampy abdominal pain located about the umbilicus. It increased over a 12 hour period and was associated with anorexia followed by sudden unconsciousness lasting about 10 minutes. After this episode he suffered mild, intermittent, crampy abdominal pain. The patient denied syphilis and had noted no coldness, paresthesias or claudication pains in the legs. He had not been aware of an abdominal mass, pulsations or back pain.

Physical examination revealed a firm, pulsating mass to the left of the midline, measuring 10 by 14 cm., and extending from the epigastrium to the level of the iliac spine. The femoral, dorsalis pedis and posterior tibial pulses were felt.

An abdominal aortogram revealed a large aneurysmal dilatation of the abdominal aorta with associated soft tissue mass, which undoubtedly represented laminated clot.

Course. Six days after admission, a resection of the abdominal aorta was carried out by Dr. Edward Keefer because of a large, ruptured aortic aneurysm. A homologous arterial graft was inserted below the renal arteries and including the aortic bifurcation (figs. 5 to 8). The patient was on the table thirteen and one-half hours. He received 8,650 ml. of whole blood. He had a rather stormy postoperative course but gradually improved. His dorsalis pedis and posterior tibial arteries continued to be patent. On the twenty-eighth postoperative day he was discharged from the hospital without pain. His
only complaint was minimal weakness after being up and about for considerable periods. He is still alive two years later and doing well.

Postoperative Care. Our observations and review of such cases lead us to believe that in some instances the technical surgery has been excellent, but a leg or a life has been lost because of lack of attention to certain details during the postoperative period. We therefore suggest that particular attention be paid to the following:

1. In most patients the feet should be 6 inches below the heart level to encourage return of good arterial circulation. On many surgical services, a common procedure is to elevate the foot of the bed and thought is not given to the physiologic needs after this procedure.

2. Prophylactically, heparin should be instilled into the aneurysm or the distal iliac arteries when the proximal artery is occluded to minimize the risk of sludge or thrombus formation.

3. If there is evidence that the circulation is poor, this may well be due to sludge or soft-clot formation. Heparin should be started immediately. It should preferably be given into the femoral arteries by continuous drip or in daily amounts of 300 mg. per 1,000 ml. of 5 per cent dextrose. This will encourage disintegration of the sludge or clot rather than consolidation of it and may well save an extremity. This may be continued for 8 to 10 days or an oral anticoagulant may be substituted after the
first 3 to 4 days. The use of anticoagulants is not universal for this purpose but appears to be increasingly accepted.

4. Peripheral vasoconstricting drugs should be avoided unless vitally needed to keep the blood pressure up. They may further endanger extremities already in jeopardy from poor circulation.

5. Unless there is an overbalancing contraindication, fluids must be administered at a high level of 2,500 ml. or more a day, since dehydration encourages thrombosis.

6. The electrolyte balance should be controlled carefully.

7. Antibiotic therapy should be administered prophylactically.

8. Gastric suction should be used freely to prevent distention, paralytic ileus and pressure on the new graft site.

9. Active exercise of the lower extremities should begin with the return of consciousness.

10. The use of an oscillating bed is justified, especially if the circulation of the legs is impaired.

Indications for Resection and Graft for Abdominal Aortic Aneurysms. There are some justifiable differences of opinion regarding the indications and contraindications for this type of surgery. There are surgeons who believe that any aortic aneurysm should be operated upon, regardless of level or type. Others feel that if the aneurysm is above the renal arteries or involves the renal arteries the results will not justify the surgery. Our present indications for operation are as follows:

(1) A patient who has an abdominal aortic aneurysm and whose general condition seems good enough to tolerate surgery of this magnitude;

(2) a palpable pulsating mass in or near the midline of the abdomen (a mass increasing in size under observation makes the operation urgent);

(3) pain in this area, intermittent or persistent, especially if severe enough to require narcotics;

(4) evidence of rupture or leakage constitutes an emergency indication for operation;

(5) anteroposterior and lateral x-ray films, showing the calcific outline of an aneurysm;

(6) an aortogram, demonstrating an aneurysm that appears operable;

(7) availability of a suitable graft or prosthesis;

(8) a surgical team with sound experience with this type of surgery;

(9) the indications are the same regardless of the etiology of the aneurysm, although the outlook for syphilitic aneurysms (fortunately rare) is poorer than for the other types.

Indications for Great Caution or Operation Only Under Unusual Circumstances

(1) Recent or repeated myocardial infarction;

(2) definite evidence of coronary insufficiency, (some surgeons suggest the simple operation of wrapping the aneurysm, if progression forces an operation in the face of either of these two contraindications);

(3) extreme hypertension, e.g., 240/140 mm. Hg, which should be reduced prior to operation, if possible;

(4) marked arterial insufficiency of the lower extremities with risk of, or impending, gangrene;

(5) involvement of the renal arteries with renal insufficiency.

Absolute Contraindication. The presence of another disease that will inevitably kill the patient within a short time.

Results of Surgery. The immediate results appear to justify the surgical approach, when the criteria outlined above are utilized. The results appear to maintain a favorable balance throughout a two-year follow-up period. There are an insufficient number of patients who have been followed for a longer period to make final conclusions possible regarding a long-range comparison with untreated cases.

Conclusions

1. Technical advances in the surgical treatment of abdominal aortic aneurysm justify further examination of this approach.

2. The great majority of abdominal aortic aneurysms are arteriosclerotic; syphilitic and mycotic aneurysms are now very rare.
3. The life expectancy is poor, with 85 to 95 per cent of the patients dying within 5 years of the diagnosis. This type of aneurysm should be regarded as seriously as cancer.

4. The symptoms and signs are varied and often masked by other pathologic processes but their careful analysis frequently leads to the correct diagnosis.

5. Roentgenographic studies, both with standard technics and visualization with contrast media, are usually helpful in confirming the diagnosis.

6. Each case should be analyzed in terms of suitability for surgery, and the great majority can be successfully operated upon.

7. Various types of surgical approach have been tried, but today the emphasis is on resection of the aneurysm and its replacement by a graft.

8. Homologous aortic grafts are more widely used at present, but plastic grafts of Nylor, Orlon, and Vinyon are being tried and will possibly be used in the majority of cases in the future.

9. The indications, reasons for caution and contraindications have been analyzed.

10. Rupture of an abdominal aneurysm is the most common fatal complication, but with modern technic and prompt action, an increasing number of these cases are being successfully operated upon.

11. The technical advances of surgery have greatly improved the outlook for the treatment of the aneurysm itself, but it must be borne in mind that most of these patients are over 60 years of age and have widespread vascular disease or other malignant disease from which more than 50 per cent of them will die within five years.

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Re-opening the Case of the Abdominal Aortic Aneurysm
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