

tients developed myalgia, fever, diarrhea and fatigue; some had peri-orbital edema, abdominal cramps, visual disturbances, nausea or vomiting, skin lesions or dyspnea. The length of the illness was from a few days to more than two months; recovery was often protracted. Seven patients were admitted to hospital but none died.

Résumé

Trichinose provoquée par ingestion de viande d'ours et de produits à base de viande de porc avariée: épidémie majeure en Colombie Britannique en 1971

En 1971, 17 personnes résidant en Colombie Britannique ont contracté la trichinose après avoir mangé de la viande d'ours noir (*Euarctos americanus*) insuffisamment fumée ou des produits à base de porc avariée. Après une période d'incubation variant de trois à 24 jours (moyenne de 14 jours) les malades présentaient de la myalgie, de la fièvre, de la diarrhée et de la fatigue; certains avaient un oedème périorbitaire, des coliques abdominales, des troubles visuels, de la nausée et des vomissements, des lésions cutanées ou de la dyspnée. La maladie a duré de quelques jours à plus de deux mois chez certains. La guérison a été souvent lente à se produire. Sept malades ont dû être hospitalisés, mais aucun décès n'a été enregistré.

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Surgical treatment of abdominal aortic aneurysms in Toronto: a study of 1013 patients

The Interhospital Cardiovascular Surgery Group of the University of Toronto* and F. M. Ameli, M.D., J. Gunstensen, M.D., K. Jain, M.D., N. Poilly, M.D., E. H. Spratt, M.D., and H. Tutassaura, M.D., **, Toronto

The experience of surgeons at three Toronto hospitals in the treatment of 1013 abdominal aortic aneurysms from 1955 to 1971 is presented.

In the first 10 years the average interhospital mortality rate for elective and ruptured aneurysms was 11.2%, in the second five years it was 9.8% and in the last two years it was 6.7%. In these three periods the percentage of ruptured aneurysms fell from 34 to 22% but the probability of survival following operation for a ruptured aneurysm remained stationary at 33%. On the other hand,

the mortality rate for elective resection of abdominal aneurysms declined from 11.25% in the first period to 6.7% in the last two years.

Risk of operation is increased in patients who are very old or who have associated coronary or generalized atherosclerosis. The present policy in Toronto is to recommend elective resection in any patient with a demonstrable aneurysm who appears to have a life expectancy of at least two years.

"There are two different kinds of aneurysms. The one occurs when there is local dilatation of an artery. The other kind arises from the rupture of an artery and the discharge of blood into the flesh beneath it. . . . It is foolish to follow the practice of the ancient surgeons and decline to treat any aneurysm but it is dangerous to apply surgical treatment to all types. . . . Those who tie the artery as I advise, at each extremity, but amputate the intervening dilated part, perform a dangerous operation. The violent tension of the arterial pnuma often displaces the ligatures." (from the

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*The Interhospital Cardiovascular Surgery Group of the University of Toronto consists of the staff cardiovascular surgeons at all the teaching hospitals. For this initial study the surgeons at St. Michael's Hospital, the Toronto General Hospital and the Toronto Western Hospital have contributed the data. The coordinators of this study were Drs. R. J. Baird, J. A. Key, and J. Yao.

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writings of Antyllus, a Greek who lived in the first century A.D. and was a contemporary of Celsus and Tiberius Caesar)¹

In the 17 years from January 1, 1955 to December 31, 1971, 1013 patients with abdominal aortic aneurysms were operated upon by the surgeons of the Interhospital Cardiovascular Surgery Group of the University of Toronto. The purpose of this article is to present this combined experience and to discuss some of the changes which have occurred in patient selection, surgical techniques and results of treatment of this lesion in Toronto.

General history of surgical repair

In 1817 Sir Astley Cooper reported that he had ligated the abdominal aorta for an aneurysm.² Thereafter surgeons occasionally introduced foreign substances into the aneurysm or wrapped it with various materials in an attempt to induce thrombosis within the dilated vessel. However, surgery was performed rarely, was hazardous, and the results were disappointing. The report of Alexis Carrel in 1907 that the abdominal aorta of a dog could be replaced with a homograft aorta did not lead to clinical application in the treatment of an aneurysm for another 47 years.³

In Paris, on March 29, 1951, Charles Dubost and his colleagues Michel Allery and Nicolas Oeconomos successfully repaired an abdominal aortic homograft. The patient was 50 years old and the surgical approach was a left thoraco-abdominal incision. The homograft, the thoracic aorta of a 20-year-old girl, had been preserved for three weeks. Their experience was reported first in the *Semaine des Hôpitaux de Paris*, September 18, 1951, and later in the March 1952 issue of the *AMA Archives of Surgery*.^{4,5} The era of curative surgery for aortic aneurysms had begun.

The first successful repair of a ruptured aneurysm of the abdominal aorta, of which we are aware, was performed in San Francisco on December 18, 1953, by Frank Gerbode and his colleagues.^{6,7}

The extremely serious prognosis of an untreated aneurysm had been well documented by J. E. Estes Jr. in an article in *Circulation* in 1950.⁸ Within one year of diagnosis one fifth of the patients, and eventually two thirds, died from rupture of the

aneurysm. At that time (1950) there was no effective method of altering this natural history. A subsequent study by Szilagyi *et al* in 1966 confirmed the lethal nature of the lesion, reported that large aneurysms were more likely to rupture than small aneurysms, and demonstrated conclusively that operative repair greatly increased life expectancy.⁹

From 1951 to 1956 a preserved homograft of abdominal aorta was the only available substitute. In 1956 the first crude arterial prostheses became available; they were rapidly simplified and improved and, since 1958, excellent Teflon or Dacron prostheses have been available to the surgeon.

Local history of aneurysmal repair

The first two attempts in Toronto to repair abdominal aortic aneurysms, both elective and ruptured, were made in November 1953.

Case 1

On November 10, 1953 a 57-year-old man complained of crampy abdominal pain which had started 24 hours previously and was now localized in the left groin. There was a large, tender, pulsating abdominal mass. He was watched for four days during which time there was little change. On November 14 the pain became worse, his abdominal girth increased, and he exhibited signs of shock. After considerable discussion with other staff members and the family, operation was recommended.

The abdomen was opened by a long left paramedian incision. There was a small amount of free blood in the peritoneal cavity and a huge retroperitoneal hematoma. The aneurysm was four inches in diameter and extended from the renal arteries to the bifurcation of the aorta. During a five-hour operation the aneurysm was resected and replaced with an aortic homograft. The patient left the operating room with a good colour, systolic blood pressure of 80 and pulsations at both ankles.

"He was seen again approximately one-half hour later and it was evident that he had suddenly gone bad as he was quite blue and no pulse or heart beat was obtainable. Cardiac massage was carried out through the fourth left interspace in the usual manner and, without too much difficulty, one was able to get the heart beating again. Unfortunately he never roused from this procedure and died six hours later." (from the operation note of D. R. Wilson)

Case 2

In May 1952 a 69-year-old man was admitted for investigation of lower ab-

dominal pain. An aortogram revealed a vascular aneurysm about 5 cm. in diameter. The wall was calcified and it seemed to be lined by a thick layer of clot. Because of the latter finding and the fact that the pain had subsided, it was decided that operation was not indicated at the moment. A malignant polyp at the rectosigmoid junction was removed *in toto* through a sigmoidoscope.

In October 1953 he was admitted with gastrointestinal bleeding. Barium enema was negative, but a gastrointestinal series showed evidence of duodenal ulceration, which was treated conservatively.

On November 21, 1953 the patient was readmitted with pain in the region of the aneurysm and the lower back. The pain persisted and operation was performed a week later. There was no evidence of bleeding from the aneurysm. The aneurysm was resected and replaced with a homograft during a period of aortic occlusion lasting 110 minutes. Femoral artery pulses were normal at the end of the procedure.

A carcinoma of the sigmoid colon was found as well. After the repair of the aneurysm, the sigmoid colon appeared cyanotic and it was decided to exteriorize and resect the lesion. The exposed ends of the colostomy became gangrenous in the next few days and the patient died on December 7, 1953. (abstracted from the operation note of W. G. Bigelow)

A few patients were operated upon successfully in Toronto in 1954. This review begins in January 1955 and thus covers almost the entire experience of the three university hospitals with major cardiovascular services.

The Toronto experience

In the 17 years from January 1, 1955 to December 31, 1971, 1013 patients with abdominal aortic aneurysms were operated upon in the Toronto General Hospital, St. Michael's Hospital and the Toronto Western Hospital. In 714 patients (70.5%) the repair was elective and in 299 patients (29.5%) the aneurysm had ruptured before operation. The ages of the patients ranged from 42 to 85, with a mean of 66 years. The male to female ratio was 4.5:1. For the entire period, the overall hospital mortality rate for elective repair was 9.7% and for repair of ruptured aneurysms was 66.2%. We define a patient with a ruptured aneurysm as one who exhibits the clinical findings of rupture before operation and who, at operation, has free blood outside the aortic wall.

The first 10 years: From January 1, 1955 to December 31, 1965, 267 elective operations (resection and graft replacement) were performed,

with a hospital mortality rate of 11.25%. During the same period 128 ruptured aneurysms were repaired, with a hospital mortality rate of 67.2%. The interhospital mortality range for elective aneurysms was 8 to 16% and for ruptured aneurysms was 51 to 78%. During this period 34% of all such operations were performed for ruptured aneurysms.

The second five years: From January 1, 1965 to December 31, 1969, 289 elective operations for aneurysms were performed, with a hospital mortality rate of 9.8%. During the same period 124 ruptured aneurysms were repaired, with a hospital mortality rate of 64.5%. The interhospital mortality range for elective aneurysms was 5 to 15% and for ruptured aneurysms was 55 to 81%. During this period 30% of all such operations were done for ruptured aneurysms.

The last two years: From January 1, 1969 to December 31, 1971, 162 elective operations for aneurysms were performed, with a hospital mortality rate of 6.7%. During the same period 47 ruptured aneurysms were repaired, with a hospital mortality rate of 68.1%. The interhospital mortality range for elective aneurysms was 3.6 to 11.5% and for ruptured aneurysms was 44 to 85%. During this period 22% of all such operations were for ruptured aneurysms.

These data are set forth in Tables I, II and III.

A comment on mortality figures

This series is unique in that it pre-

sents the experience from several hospitals in a large city rather than from one institution where, for a short period, a combination of factors may have allowed the staff to achieve outstanding results. The risk in *elective* resection of an abdominal aortic aneurysm has decreased steadily in all major centres in North America; for example, Hildebrand and Chung in Vancouver reduced the mortality in elective resection from 17.2% in the period 1955 to 1964, to 9.4% in 1965 to 1969.¹⁰ Since 1970 several centres have reported that the mortality for elective resection has been decreased to less than 5%.¹¹ The overall mortality rate for elective repair in Toronto in the two years ending December 31, 1971 was 6.7% and one of the contributing institutions reported a risk of only 3.6%.

In considering the risk of resection in *ruptured* aneurysms, we must remember that many factors are beyond the surgeon's control. In 1968 May, DeWeese and Frank¹² reported that there had been no pronounced improvement in mortality rates for ruptured aneurysms over the previous 10 years. In 1971 David and Bernatz¹³ reported that across North America surgical mortality rates ranged from 32 to 80%. However, this wide range reflects some confusion in the definition of "rupture". For example, some groups classify cases as "emergency" when the aneurysm is tender but has not yet actually ruptured, whereas in our series all patients with a "ruptured aneu-

rysm" satisfied the definition mentioned above. The overall figures from Toronto indicate that there has been no improvement in the mortality rates for ruptured aneurysms and that two thirds of the patients who survive long enough to be operated upon will die. In most cases the death can be related to the delay in reaching a surgical centre and, to a lesser extent, to associated cardiovascular disease.

As shown in Table III, in each of the three hospitals there has been a progressive decrease in the percentage of ruptured aneurysms repaired as compared with the total number of aneurysms. This decrease can be interpreted in one of three ways: more people have their aneurysms diagnosed and repaired before they can rupture; surgeons, aware of the poor survival results, refrain from operating on the elderly or moribund; or ruptured aneurysms are being treated locally as physicians recognize the hazard of delay and as techniques of vascular surgery are applied in smaller cities. All these factors are probably operating in the Toronto experience.

Changes in surgical technique

All of the surgeons in the Toronto group have continued to use Tapp-Edwards Teflon prostheses — woven or knitted — and have found them satisfactory. Although some of the surgeons continue to use silk sutures to attach the prostheses, most have changed to plastic sutures. The long midline incision is closed with interrupted sutures of no. 22 wire at one hospital and with heavy chromic catgut and retention sutures at the other two.

In very high aneurysms which encroach on the renal arteries, some surgeons obtain the necessary exposure by elevating the left renal vein, while others divide the vessel and clamp the aorta above the renal arteries throughout the performance

Table I

The risk of elective repair of an abdominal aortic aneurysm, 1955 to 1971

	Number of patients	Number who died in hospital	Mortality rate (%)	Interhospital range (%)
First ten years	267	30	11.2	8-12
Second five years	285	28	9.8	5-15
Last two years	162	11	6.7	3.6-11.5
Overall	714	69	9.7	7.4-14.6

Table II

The mortality associated with repair of a ruptured aortic aneurysm, 1955 to 1971

	Number of patients	Number who died in hospital	Mortality rate (%)	Interhospital range (%)
First ten years	128	86	67.2	51-78
Second five years	124	80	64.5	55-81
Last two years	47	32	68.1	44-85
Overall	299	198	66.2	64-70

Table III

Incidence of patients with ruptured aneurysms, 1955 to 1971

	Mean incidence (%)	Interhospital range (%)
First ten years	34	20-36
Second five years	30	16-36
Last two years	22	15-27
Overall	30	20-35

of the upper anastomosis. An analysis of 60 cases in which this vein was divided did not reveal any evidence of significant damage to the left kidney.¹⁴

Since 1963 mannitol 25 g. has been given routinely before clamping the aorta; we believe that the osmotic diuresis so induced has reduced the incidence and severity of renal tubular necrosis. In any event, this catastrophe has been encountered much less frequently in recent years. Also, the marked improvement in the management of post-operative renal failure has saved patients who formerly would have died from this complication.¹⁵

Several surgeons, who have encountered complications from the embolization of atheromatous debris from the aneurysm, routinely clamp the iliac arteries before beginning to dissect the aneurysm. The use of Weck clips to occlude the lumbar arteries has also increased the speed of resection. In ruptured aneurysms it is routine to leave the posterior wall of the aneurysm *in situ*; in elective resection it may be left or removed at the discretion of the surgeon. The time on the operating table now averages two to three hours.

Factors affecting the risk of operation

The operative risk is increased in patients who are very old or have associated coronary or generalized atherosclerosis. In the 11 patients (6.7%) who died following elective resection during the last two years, the causes of death were as follows: pulmonary embolism (2), myocardial infarction (4), respiratory failure (2), cerebrovascular accident (2) and postoperative hemorrhage from infection of the graft (1).

Of the 32 patients who died following resection for rupture in the last two years (68%) the causes of death were: hemorrhage leading to irreversible shock and death in the operating room or in the recovery room during the next 24 hours (20, including a Jehovah's Witness who refused blood transfusions), myocardial infarction (6), pulmonary embolism (2), renal failure (2), respiratory failure (1) and anastomotic rupture (1).

Present policy and future directions

Our present policy in regard to elec-

tive aneurysms is to recommend operation for any patient with a demonstrable aneurysm who appears to have a life expectancy of at least two years. The recommendation is very clear in younger patients and those with large aneurysms. It is less clear in the elderly and those with evidence of coronary or cerebral atherosclerosis. Operation has been recommended in only a few patients past the age of 80 and in none over 85 years of age.¹⁶ With this policy mortality rates, which now approach 5%, will probably remain at or near this level.

The patient whose aneurysm suddenly enlarges, becomes tender or is associated with abdominal pain is advised that the situation is *urgent* and repair is performed as soon as possible. For the purpose of this review such cases have been included in the elective group.

A successful outcome for the patient with a *ruptured* aneurysm depends mainly on the length of the interval from rupture to repair. With increasing physician and public awareness of the natural history of abdominal aneurysms, the surgeon should see fewer patients with ruptured aneurysms. The figures presented in this article indicate that this trend is already detectable. In the future in Canada, the increasing number of surgeons who are trained in vascular procedures and the improved efficiency of ambulance and blood bank services should shorten greatly the interval between onset of symptoms of rupture and definitive surgical treatment. We have reason to hope that the very high mortality rates from this catastrophe will then decline somewhat.

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Résumé

Le traitement chirurgical des anévrismes de l'aorte abdominale à Toronto: observations de 1013 cas
Les auteurs rapportent l'expérience de chirurgiens pratiquant dans trois hôpitaux de Toronto qui ont opéré 1013 cas d'anévrismes de l'aorte abdominale de 1955 à 1971.

Durant les 10 premières années, la mortalité moyenne des trois hôpitaux pour des opérations électives ou des ruptures d'anévrisme était de 11.2%, au cours des cinq années

suivantes de 9.8% et durant les deux dernières années de 6.7%. Au cours de ces trois périodes, le pourcentage des ruptures d'anévrisme tomba de 34 à 22%, mais la probabilité de survie post-opératoire d'un anévrisme rupturé est restée stationnaire à 33%. Par contre, le pourcentage de mortalité des résections électives d'anévrismes abdominaux a décliné de 11.25% qu'elle était durant la première période à 6.7% dans les deux dernières années.

Le risque opératoire augmente chez les malades très âgés ou qui souffrent en même temps d'athérosclérose coronaire ou généralisée. Actuellement, à Toronto, on préconise une résection élective chez tout malade qui présente un anévrisme patent et dont la longévité probable est d'au moins deux ans.

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