Occasional review

Norman Dott's contribution to aneurysm surgery

Nicholas V Todd, Jane E Howie, J Douglas Miller

Abstract

Between 1926-36 Norman Dott managed 39 patients with suspected intracranial haemorrhage. During this period he established important principles of diagnosis and developed new methods for the medical and surgical treatment of aneurysmal subarachnoid haemorrhage. Dott performed the first intracranial operation to treat an aneurysm and the first angiogram to demonstrate an intracranial aneurysm. This article reviews Dott's early experiences of aneurysmal subarachnoid haemorrhage.

Norman McComish Dott was a pioneer of British neurosurgery and he made an important contribution to the care of patients with aneurysmal subarachnoid haemorrhage. Between 1926-31 he managed eight patients with suspected subarachnoid haemorrhage; in three of these cases an aneurysm was demonstrated at necropsy. In 1931 he became the first surgeon to perform an intracranial operation for the treatment of an aneurysm and between 1931-36 he managed a further 31 patients with possible subarachnoid haemorrhage and operated on 11 of them. This article reviews these early experiences of Norman Dott and is based on a review of his notes, radiographs and operative drawings for this period.

Born in 1897, Norman Dott graduated in medicine in 1919 from the University of Edinburgh, having turned to medicine from his original intention of becoming an engineer during a period in hospital. He qualified FRCS(Ed) in 1923 while undertaking original experiments on pituitary secretion with Sharpey Schafer the Professor of Physiology. For this work he was awarded a Rockefeller travelling scholarship and worked with Harvey Cushing in Boston from 1923-24. Attracted to neurological surgery Dott returned to Scotland with the intention of establishing this new speciality in Edinburgh and he originally practised neurosurgery privately at the Nursing Home, 19 Great King Street, Edinburgh while continuing his practice of paediatric surgery at the Royal Hospital for Sick Children.

The clinical presentation of subarachnoid haemorrhage had been known for forty years before Dott returned from Boston; important contributions were made by Sir Byrom Bramwell and Charles Symonds amongst

others.¹⁻⁴ The first patient with subarachnoid haemorrhage to be treated by Dott was admitted on 4 October 1926. Mrs MacGregor was 47 and had a sudden onset of severe headache associated with vomiting ten days before admission. She re-bled on the tenth day, lost consciousness and on recovery was found to have a right hemiparesis with global dysphasia. Dott performed a lumbar puncture and obtained blood stained cerebrospinal fluid (CSF). He commented "The findings . . . when taken together form a very perfect picture of leakage from an intracranial aneurysm, the aneurysm being situated above the tentorium and on the left side of the head." His provisional diagnosis was "Aneurysm at bifurcation of left internal carotid with recurrent leakage." Treatment included codeine and venesection of 550 ml of blood when her blood pressure rose to 145/105. A further coma-producing haemorrhage occurred on the fifteenth day and she died two days later. At necropsy a 4 mm ruptured aneurysm of the terminal left internal carotid artery was shown.

During the next five years Dott managed eight patients with possible or proven intracranial haemorrhage, in three subarachnoid haemorrhage was proven by lumbar puncture. During this period Dott recognised different presentations of ruptured intracranial aneurysm, the oculoparetic, the apoplectic and the tumour-like⁴ and he also recognised that there were different aetiologies of intracranial haemorrhage such as haemorrhage associated with severe hypertension, haemorrhage associated with syphilis, and haemorrhage into tumours.

Dott managed a single subarachnoid haemorrhage with bedrest, analgesia and avoidance of straining at stool. Bedrest was used for the first week or so after haemorrhage then Dott recommended a rapid return to normal activities with limitation only of particularly strenuous sports, "he should be cautioned against strenuous physical exercise for example, playing rugby, boat-racing and such like". Hypotension was induced with drugs if a moderate blood pressure reduction was required and by venesection if a rapid reduction seemed appropriate. Dott was nevertheless aware of the risks of induced hypotension and recognised the compromise between sufficient blood pressure for cerebral perfusion and sufficient hypotension to reduce the risk of re-bleeding. In a 76 year old woman with long-

Department of
Neurosurgery,
Institute of
Neurological Sciences,
Southern General
Hospital, Glasgow
N V Todd
J E Howie
J Douglas Miller

Correspondence to:
N V Todd, Department of
Neurosurgery, Institute of
Neurological Sciences,
Southern General Hospital,
Glasgow G51 4TF, United
Kingdom.

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standing hypertension and a blood pressure of 255/130 Dott commented "I do not think that any measures designed to reduce blood pressure would be advisable because she requires this blood pressure to nourish her tissues and the aneurysm must just take its chance".

Dott felt that raised intracranial pressure almost inevitably followed subarachnoid haemorrhage and he distinguished three mechanisms: (1) the presence of a haematoma "the dura was extremely tense and obviously dark in colour from underlying blood . . . semi-solid blood clot was forced out under great pressure", (2) oedema around a haematoma "her present symptoms are due to increasing intracranial pressure from oedema around a clot", (3) hydrocephalus".¹¹ "The operator's impression was of chronic serous meningitis, probably the consequence of a profuse subarachnoid haemorrhage and a blockage of the fluid pathways over the convex surface of the brain". Dott mainly used lumbar puncture to reduce intracranial pressure, he used ventricular drainage in only one patient; infusions of hypertonic saline were occasionally used either rectally or intravenously.

He was concerned about the problem of re-bleeding following an initial subarachnoid haemorrhage and the possibility of preventing re-bleeding. He felt that following a single aneurysmal haemorrhage there might be sufficient thrombosis within and fibrosis around an aneurysm to prevent re-bleeding; "firm clot had formed around and almost certainly within the aneurysm . . . he may be permanently cured from this process". "There is a reasonable possibility of spontaneous fibrosis and cure as the clot around the aneurysm becomes organised". However he began to "appreciate the sinister significance of a recurrence", "again recurrent attacks at short intervals proved rapidly fatal."⁴ He also noted that further haemorrhage was often more serious than the initial bleed "the second haemorrhage concurred with my previous experience in that it was much more locally damaging than the first one" (case). He understood that re-bleeding might be minimised if arterial pulsation within the sac was reduced. His first patient with subarachnoid haemorrhage was admitted in 1926. "It was decided to compress the left internal carotid by means of a screw clip. A special clip was made for the purpose and all preparations were made to carry out the operation under local anaesthesia. A few minutes before the time arranged for the operation a third apoplectic seizure occurred from which the patient did not recover". The emotions Dott must have felt at this aneurysmal re-bleeding just before the operation will be familiar to neurosurgeons today.

Dott's historic contribution to aneurysm surgery was to consider and carry out direct intracranial exposure of a ruptured aneurysm with reinforcement of the aneurysm by wrapping it with muscle. "We were accustomed to deal successfully with quite formidable intracranial haemorrhages during operations by applying to the bleeding point a fragment of fresh muscle which formed a secure scaffolding

for the clot, and became organised into fibrous tissue with it. Why not expose a bleeding aneurysm and deal with it after this fashion?"⁴

Colin Black was a 53 year old Edinburgh solicitor and a governor of the Royal Hospital for Sick Children in Edinburgh. On the 6 April 1931 "he was struck by a sudden and extremely severe pain affecting chiefly the back of the head and neck . . . there was a curious tingling feeling, worse on the left side. Half an hour after the onset of this condition he vomited, and he vomited frequently during the next twenty-four hours". The diagnosis was confirmed by lumbar puncture and "complete rest and particularly avoidance of strain of any sort commenced". Dott arranged for bed rest at home, regular enemas and then satisfied with his arrangements he wrote in the notes "at this time I went on holiday myself". Eight days later Colin Black had a further haemorrhage and fourteen days after his initial haemorrhage he had a third coma-producing haemorrhage. Dott quoted his previous experience with recurrent aneurysmal haemorrhage "in the other two . . . there were recurrent haemorrhages at short intervals as in Mr Black's case. Both of these terminated fatally in a few weeks from a recurrent fatal haemorrhage". Dott discussed the problem with the general practitioner, Dr Crone, Professor Fraser, and the patient's wife. "My view was that it was certainly a case of spontaneous subarachnoid haemorrhage from an aneurysm on the Circle of Willis . . . the chances of spontaneous recovery considering the frequent recent recurrences were very poor indeed, probably not more than 10% . . . the technical difficulties of exposing the aneurysm obscured in surrounding clot etc, would be great and it was uncertain whether the application of muscle would control it or not. So far as I know such an operation has not previously been attempted". Dott summarised his feelings: "we tried the apparently desperate measure of directly exposing the aneurysm".

On 22 April 1931 at 11 am under ether anaesthesia a bicoronal scalp flap and an osteoplastic left frontal bone flap were raised (figure 1). The left carotid artery was approached subfrontally and "the whole length of the left optic nerve was now in view . . . the arachnoid was divided further laterally exposing the left internal carotid artery". The carotid was followed up to the bifurcation where "a comparatively recent blackish clot . . . was gently detached . . . with a blunt spoon". The middle cerebral artery was "literally dug out of blood clot. As this was being done some frank arterial bleeding occurred, this appeared to come from the posterior surface of the middle cerebral artery about 1 cm from its origin".

Neurosurgeons today will be familiar with the sensation induced by rupture of an aneurysm during its exposure. Dott controlled the haemorrhage by applying muscle "steadily maintained for twelve minutes"⁴ and wrapped the aneurysm: "muscle was now carefully packed in such a way as to clothe the middle cerebral artery for its first 2 cms in quite a thick layer of muscle". Dott performed a subtemporal decompression before closing the

Figure 1 Dott's drawing of the first intracranial operation for aneurysm. Through a left frontal flap the proximal middle cerebral artery aneurysm was exposed and wrapped with muscle.

wound, "the operation occupied three hours forty minutes". Mr Black's post operative progress was noted in the Red Cross Report Book for Nurses and on the first day post operatively the Night Report states "awake and was turned on left side, asked the time and wanted more bed clothes put on. Pulse fair". Colin Black made an excellent recovery and returned to work and to his sporting pursuits. Both he and Norman Dott were keen fishermen and they fished together on a number of occasions. Colin Black died eleven years after his operation with no further haemorrhage and Dott added a progress note in his usual meticulous way, "patient lived without further cerebral trouble until September 1942 when he died of a coronary thrombosis while deer stalking".

Dott wrapped two further aneurysms in 1931

and 1932 (figure 2). Both patients had progressive visual failure and a preoperative diagnosis of tumour. Aneurysms found at operation were wrapped. One had a fatal haemorrhage twenty four hours after operation, the other died at five days of pneumonia. Haemostatic clips were introduced by Cushing in 1911 and the first aneurysm clipping was performed in 1937 by Dandy, six years after Dott's first intracranial operation.⁶

Carotid ligation was first used by Paré in 1585 to control bleeding following stabbing and was used by Sir Astley Cooper in 1805 to treat an extracranial carotid aneurysm. Dott considered carotid ligation in the first patient with subarachnoid haemorrhage admitted in 1926 but his first carotid ligation for an intracranial aneurysm was performed on 27 October 1932. A 26 year old nurse (Isobel McNeil) had a coma-producing haemorrhage confirmed by lumbar puncture and associated with an incomplete left oculomotor palsy, "the patient was suffering from leakage from a basal aneurysm . . . the left 3rd nerve paresis is significant . . . an aneurysm of the left internal carotid". She recovered consciousness with progressive headache and papilloedema and Dott performed bilateral subtemporal decompressions. On 23 October the decompressions became suddenly tense and Dott commented "I suspect . . . a further leak from the aneurysm. This reinforced my decision to take the comparatively small risk of tying the left internal carotid artery" and under local anaesthesia "the artery was permanently ligated by means of a leash consisting of four waxed silk threads". Isobel McNeil subsequently returned to her nursing duties.

From 1932-36 Dott performed internal carotid ligation in eight patients, in six of these the aneurysm was proven by angiography to be on the internal carotid artery, in one patient the aneurysm was on the middle cerebral artery and in one the aneurysm site was unknown. The results of these early carotid ligations were good with five of his eight patients alive and well without evidence of recurrent haemorrhage. Dott used carotid ligation "In young persons and especially in cases of recurrent bleeding at short intervals active treatment is indicated. My feeling at present is that in patients over 40 with only one attack of haemorrhage there is less risk in leaving alone than in arterial ligation or in direct exposure of the aneurysm"; treatment was used for intradural but not cavernous aneurysms "these extradural aneurysms are not very prone to a fatal rupture". He also appreciated that carotid ligation was likely to be useful only for aneurysms proximal to the carotid bifurcation. "When the aneurysm is situated on the Circle of Willis or distal to it, carotid ligation is of course of no practical value" and concerning a patient with a middle cerebral artery aneurysm: "could not possibly have benefited by carotid ligation as the anastomotic circulation beyond the Circle of Willis would have continued to supply the aneurysm quite freely". Unfit or elderly patients were not considered for operation: in a 76 year old woman with severe

Figure 2 Dott's drawing of his second aneurysm wrapping. This left carotid aneurysm was exposed through a right frontal approach and partially wrapped with muscle.

Figure 3 The first angiogram to demonstrate an intracranial aneurysm. Thorotrast was injected into the exposed carotid artery by direct puncture and after demonstration of the aneurysm the carotid was ligated.

hypertension: "Carotid ligation would be out of the question in a patient of this age and with this vascular system". Risks of surgery were only infrequently mentioned: "I put it to him that the immediate risk to life attending such an operation was about one in twenty".

Dott dramatically improved his methods of diagnosis with the introduction of angiography. Equipment capable of performing angiography was installed in Edinburgh soon after the original description of the technique by Moniz and Dott quickly utilised the new method to identify an arteriovenous malformation, "Our earliest attempts at cerebral arterial radiography were made in 1927 when we used Sodium Iodide as the opaque medium." On 24 March 1933 Dott performed the first angiogram demonstrating an intracranial aneurysm (figure 3).

Catherine McKenzie was a 23 year old woman who presented with haemorrhage and a left oculomotor palsy. Contrast angiography demonstrated the expected ICPC aneurysm and the internal carotid artery was ligated. Mrs McKenzie had two possible re-bleeds at ages 26 and 44 and finally died at the age of 47 of liver metastasis. Dott's standard angiographic technique was to expose the internal carotid artery under 1% novocaine adrenalin infiltration. The consequences of internal carotid occlusion were tested "stoppage of the artery gave the patient no inconvenience whatsoever", than 12–15 ml, thorotrast were injected by direct puncture and a radiograph taken. If this confirmed an aneurysm the internal carotid artery was ligated and divided. In the 24 patients admitted with suspected or proven subarachnoid haemorrhage after 1933, Dott performed six angiograms, one failed because of problems in exposing the radiograph plate, four demonstrated carotid aneurysms and one showed a middle cerebral artery aneurysm. Dott used angiography only where surgery was being considered, usually in cases of recurrent haemorrhage. He then tied the carotid artery if appropriate.

Dott had three patients with intracranial aneurysms diagnosed either pre- or intra-operatively, between April 1931 and March 1932 and he performed aneurysm wrapping in

all three cases. What is of interest, however, is that despite seeing a further 29 patients with suspected or proven aneurysmal subarachnoid haemorrhage from March 1932 to April 1936 he did not wrap another aneurysm during this period. From 1932 to 1936 Dott performed eight carotid ligations for aneurysmal subarachnoid haemorrhage. This apparent turning away from intracranial surgery is confirmed when we examine his further cases seen up to the outbreak of the Second World War. Between 1936 and 1939 Dott saw a further 28 patients with suspected or proven aneurysmal subarachnoid haemorrhage. He performed five carotid ligations and no wrappings. It is unclear why Dott turned away from intracranial surgery. One obvious explanation is that six of the eight patients considered for operation had proven or probable carotid aneurysms which could be treated by carotid ligation, avoiding the risks of intracranial surgery. Certainly Dott continued to consider intracranial exposure with aneurysm wrapping "this procedure (wrapping) might well be contemplated if further haemorrhage occurred."

However, in 1936 in a patient with a right middle cerebral artery aneurysm proven by angiography he performed carotid ligation. The patient died, and Dott commented "this aneurysm was situated beyond the circle of Willis and was not one likely to be favourably affected by carotid ligation. Nevertheless, . . . the internal carotid artery was ligated"; despite his earlier experience with aneurysm wrapping Dott concluded "in such cases as this . . . it is very difficult to see what practical measures can be taken". This seems to be evidence that Dott had abandoned the intracranial operation perhaps because in this early series his operative mortality was 66% for the intracranial operation and only 25% for carotid ligation.

Norman Dott was Britain's first full time neurological surgeon. In addition to a number of other important contributions he developed guidelines for the management of patients with subarachnoid haemorrhage, devised various medical therapies and introduced angiography for pre-operative diagnosis of aneurysms. He introduced criteria for carotid ligation for intracranial carotid aneurysms and described the first intracranial operation for aneurysm with a successful outcome following wrapping.

- 1 Bramwell B. Clinical and pathological memoranda. *Edin Med J* 1886;xxii:97–108.
- 2 Drennan AM. Aneurysms of the larger cerebral vessels. *New Zealand Med J* 1921;xx:324–48.
- 3 Bramwell E. A case of leaking aneurysm of the Circle of Willis and two cases of recurrent oculomotor paralysis—a clinical comparison. *Edin Med J* 1931;xxxviii:689–99.
- 4 Symonds CP. Spontaneous subarachnoid haemorrhage. *Q J Med* 1924–5;18:93.
- 5 Dott NM. Intracranial aneurysms. Cerebral arteriography: Surgical treatment. *Tr Med Chir Soc Edin* 1932–33. *Edin Med J* 1933:219–34.
- 6 Dandy WE. Intracranial aneurysm of the internal carotid artery: cured by operation. *Ann Surg* 1938;107:654–9.