Direct measurement of mean and pulsatile blood pressure at operation in human intracranial saccular aneurysms

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Mean and pulsatile intra-aneurysmal blood pressures were recorded from four cases of human intracranial saccular aneurysms at the time of operative exposure. In each case the mean intra-aneurysmal pressure equalled the mean systemic arterial pressure, and the intra-aneurysmal pressure was pulsatile. The results demonstrate that, contrary to the findings of another report, intracranial aneurysms are subjected to the full force of systemic blood pressure.

Key Words: cerebrovascular hemodynamics • intracranial aneurysm • intra-aneurysmal pressure

There have been a number of reports on the direct measurement of blood pressure in human intracranial arteries. These studies have shown that there is no significant pressure drop between the arteries in the neck supplying the brain, and the major intracranial arteries. Because of the possible dangers involved in obtaining the measurements, there is very little comparable information regarding intra-aneurysmal pressure; at least one author has assumed that the pressure within intracranial aneurysms is similar to that in the intracranial arteries.

To obtain more information on this subject, a study was carried out in conjunction with a previously reported investigation of turbulence in human intracranial saccular aneurysms to determine whether mean intra-aneurysmal pressure is equal to systemic arterial pressure, and whether intra-aneurysmal pressure is pulsatile.

Method

To record the blood pressure from intracranial aneurysms during their surgical exposure, a 22-gauge needle with a metal shaft was used. This was connected by a 100 cm length of fine polyethylene tubing to an electronic pressure transducer (Statham Model P23DEc), the output of which was recorded on a paper chart-recorder (Beckman Type R Dynograph). This length of connecting tubing was necessary in order to position the transducer well away from the sterile operative field. Either a 1.5 or 4 in. needle, and polyethylene tubing of an internal diameter of either 0.030 in. (PE 60 Clay Adams Intramedic) or 0.047 in. (PE 190 Clay Adams Intramedic), were used depending on the requirements of the experiment. The PE 60 tubing is known to give a faithful reproduction of the pulse pressure contour, while the PE 190 tubing provides a damped, or mean, recording of pressure. A second pressure transducer was used to record simultaneously systemic arterial pressure from the radial artery at the wrist. The pressure transducers were calibrated at the beginning and end of each experiment with a mercury ma-
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nometer. The reference level for both transducers during recordings was the mid-axillary line, except in Case 4.

Because of the uncertainty of inserting a relatively large bore needle into a thin-walled aneurysm, cases were chosen with great care. The ultimate decision to proceed in each case was made by the operating surgeon. Recordings were made only in those cases in which the aneurysm and its neck had been uneventfully and completely dissected; and in which it was felt that a clip could be applied safely and easily, if rupture of the aneurysm and uncontrollable bleeding resulted from insertion of the needle. The needle was inserted into the sac of the aneurysm, well away from the neck. When the needle was removed, the aneurysm was clipped immediately. Except in Case 4, recordings were made at hypotensive levels of systemic pressure, since it is the practice of the Neurosurgical Unit at the University of Western Ontario to operate on all aneurysms using hypotension produced by the intravenous administration of Arfonad.*

Intra-aneurysmal pressure measurements were made in four cases. There were no unusual difficulties with bleeding, and no complications from the procedure, in any of the cases.

Case Reports

Case 1

This 52-year-old woman had had a hemorrhage from a large bilocular middle cerebellar bifurcation aneurysm while bending over to pick up her shoes. The 1.5 in. needle and PE 60 tubing were used to make an excellent pulsatile intra-aneurysmal pressure recording, which exactly followed the systemic arterial pressure (Fig. 1). At the moment of insertion of the needle into the aneurysm, the pulsatile radial artery pressure was 58/40, and the calculated mean pressure† was 46 mm Hg. The intra-aneurysmal pressure recorded simultaneously was 60/42 (mean pressure, 48 mm Hg). After a 30-sec interval, during which the systemic pressure rose, the radial artery pressure was 72/52 (mean pressure, 59 mm Hg) and the corresponding intra-aneurysmal pressure was 75/44 (mean pressure, 61 mm Hg).

Case 2

This 30-year-old woman bled from a large bilocular anterior communicating artery aneurysm. Because of the depth of the aneurysm within the skull, the 4 in. needle connected to the PE 60 tubing was used. The systemic pressure was 54/36 (mean, 42 mm Hg) and the intra-aneurysmal pressure 48/40 (mean, 43 mm Hg) (Fig. 2). Although the pulse pressure in the aneurysm (8 mm Hg) appeared to be considerably less than that in the systemic circulation (18 mm Hg), this difference was almost certainly the result of damping of the aneurysmal pulse pressure by the 4 in. needle, as will be discussed below.

Case 3

This 43-year-old woman bled from a moderately large basilar bifurcation aneurysm. The 4 in. needle connected to the PE 190 tubing was used. This system damped the pressure oscillations almost completely, such that mean intra-aneurysmal pressure was recorded for comparison to mean sys-

* Arfonad, trimethaphan camphorsulfonate, Hoffman-La Roche Ltd., Montreal, Canada.
† Calculated mean arterial blood pressure is the systolic pressure added to 2 times the diastolic pressure, all divided by 3.

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Case 2

Anterior communicating artery aneurysms. Dynograph chart record of pulsatile intra-aneurysmal and systemic arterial pressures.

The mean intra-aneurysmal pressure was 60 mm Hg; the mean systemic pressure, 59 mm Hg.

Case 4

This 38-year-old man had a hemorrhage from a pericallosal artery aneurysm. A continuous recording of radial artery pressure was not available in this case. Therefore, brachial cuff pressures were used. The 1.5 in. needle and PE 60 tubing were used. Intra-aneurysmal pressure was 100/80 (mean pressure, 87 mm Hg) (Fig. 4). Brachial cuff pressure was 135/80 (mean pressure, 98 mm Hg). The head was elevated in this case, such that the level of the aneurysm was 15 cm above that of the brachial artery. The pressure transducer was at the level of the aneurysm. If allowance is made for this difference in height, by adding 11 mm Hg pressure* to the mean intra-aneurysmal pressure, a mean value of 98 mm Hg is obtained, which is identical to the calculated mean systemic pressure. The difference in pulse pressure (55 mm Hg versus 20 mm Hg) reflects the difference in the methods of recording pressures. In this case, the limits of systole and diastole were found more accurately with the cuff measurements.

The effect of the various combinations of tubing and needle size in damping pulsatile pressure measurements was investigated by comparing the pressure values obtained from the radial artery of patients using each combination in turn. The 4 in. needle and 190 tubing damped pulse pressure almost completely, as in Case 3. There was much less damping with the PE 60 tubing. The 1.5 in. needle and PE 60 tubing produced the least damping, as in Case 1.

Discussion

The only previous report on intra-aneurysmal pressure is that of Wright, who studied three cases of middle cerebral bifurcation aneurysm. In two of his cases, the mean intra-aneurysmal pressure was only one-third of the systemic pressure, and in the third case it was slightly less. The pressures were pulsatile, but intra-aneurysmal pulse pressures were much less than systemic arterial pulse pressures. These low values must

* Since 1 mm of mercury produces a pressure equivalent to 1.36 cm of water, 15 cm of water is equivalent to 11 mm Hg of pressure.

Fig. 2. Case 2. Anterior communicating artery aneurysms. Dynograph chart record of pulsatile intra-aneurysmal and systemic arterial pressures.

Fig. 3. Case 3. Basilar bifurcation aneurysm. Dynograph chart record of the simultaneous recording of mean intra-aneurysmal and systemic arterial pressure. Arrows indicate the moment of insertion of the needle into the sac of the aneurysm and its withdrawal. The total recording time was 25 sec.

Fig. 4. Case 4. Pericallosal artery aneurysm. Dynograph chart record of pulsatile intra-aneurysmal pressure. Arrow shows where the pressure scale was halved.
be considered suspect, for if they are correct, they indicate that there is a pressure gradient for flow into, but not out of, an intracranial aneurysm. This would result in no intra-aneurysmal flow, which is clearly not the case. This has been demonstrated both in models and in human aneurysms at the time of surgery.^

On the basis of the study reported here, the following conclusions can be made regarding human intra-aneurysmal blood pressures. First, the mean intra-aneurysmal pressure, as measured in aneurysms at four different sites in the circle of Willis, is equal to the mean systemic arterial pressure, within the errors of measurement of the apparatus used (± 2 mm Hg). Any differences in the mean pressures may be accounted for by differences in the height of the aneurysm and the recording site for systemic pressure. Thus, in a patient, intra-aneurysmal pressure will be greater when he is lying than when he is sitting or standing. Second, the pressure within an aneurysm is pulsatile. This agrees with the observation made commonly by surgeons, that intracranial saccular aneurysms appear to pulsate. Finally, the intra-aneurysmal pulse pressure is likely the same as the systemic pulse pressure. The damping of the intra-aneurysmal pulse pressure in Cases 2 and 4 is explained by the characteristics of the recording apparatus.

The results of this study indicate that there is no significant difference in systemic and intra-aneurysmal blood pressure, and that human intracranial saccular aneurysms thus experience the full force of systemic arterial pulsatile pressure. The relation of this finding to the stress in the wall of an aneurysm, and how it affects the likelihood of rupture, will be reported elsewhere.^

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