Monitoring Circulatory Changes during Subdural Hematoma Aspiration

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Aspiration of subdural hematomas in infancy can result in patient distress and occasional death. A method is described in which ^{113m}In was injected intravenously to measure circulatory changes during the aspiration of a subdural hematoma in a 9-month-old child. The observed increase in blood volume in the head did not correspond exactly with the volume of fluid aspirated although the 4–7% increase in blood volume that occurred during aspiration could account for the observed distress by hypovolemic shock due to the sudden shift of blood into the intracranial veins. In addition, negative pressure aspiration could induce fresh bleeding into the subdural space.

Much more attention has been paid to the measurement of blood flow and pressures, even transit times, than to the capacity of the vascular bed. In certain instances, a change in the capacity of the vascular bed is clearly the primary hemodynamic change, as in hypotension due to fainting or paraplegia.

Since it has been suggested by Martin, et al *(1)* that deaths due to tapping infantile subdural hematomas may be due to an increase in the capacity of the vascular system within the skull, we devised a method of determining both the relative and absolute changes in capacity in any part of the vascular bed of an infant. Using this method we were able to monitor circulatory changes occurring during the aspiration of recurrent bilateral subdural hematoma in a 9-month-old child and the rate at which these changes occurred.

Materials and Methods

The circulatory changes were measured by labeling the plasma with ^{113m}In as indium chloride (half-life, 1.7 hr) which, when given intravenously, results in almost instantaneous binding of the indium to transferrin, forming a relatively stable blood marker *(2)*. Using Medical Internal Radiation Dose Committee data and assuming that the circulatory biologic half-time of the indium–transferrin complex is 3 hr *(3)*, the whole-body radiation dose was calculated to be approximately 180 mrads for a total dose of 3 mCi.

After allowing a few minutes for uniform distribution of labeled plasma throughout the body, the child was positioned under a Searle Pho/Gamma III HP scintillation camera, using a high-energy diverging collimator set at such a distance that the entire body was included in the field of view. The distribution of ^{113m}In activity was recorded on videotape before and after aspiration of subdural fluid. Aspirations were carried out using a 10-ml syringe and a 23-gage needle through the lateral part of the fontanelle.

Results

The first time the child was aspirated only 15 ml of subdural fluid was withdrawn and no change in the distribution of radioactivity, as determined by counting rates within the selected regions, was observed (Table 1).

After the completion of the second aspiration, when 75 ml of subdural fluid was withdrawn, a shift of 7% of the total activity into the head was found.

TABLE 1. Blood Activity Changes

Aspirated volume (ml)	Activity change (%)	Blood volume change (ml)
15	Negligible	Negligible
75	7	49
60	4	24

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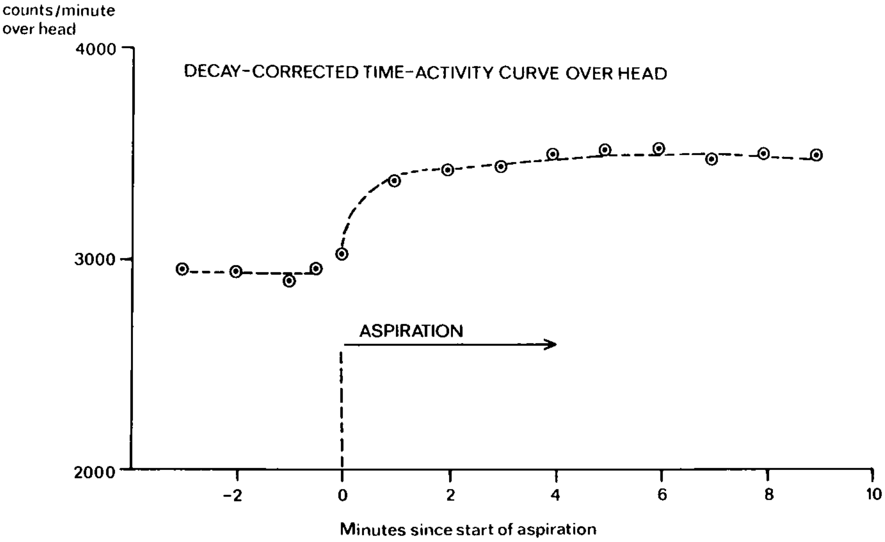

FIG. 1. Decay-corrected time-activity curve showing increase in activity in head following aspiration.

The third aspiration was terminated after 75 ml of fluid had been removed because of fresh bleeding into the subdural space. Since old blood in the subdural space did not contain radionuclide, the volume of fresh blood in the sample was calculated from its radioactivity and subtracted so that in fact only 60 ml of actual subdural fluid was removed. On this occasion, the child was anesthetized and it was therefore possible to monitor the rate of change of plasma distribution during the procedure by selecting regions of interest before aspiration, one to include the head and the other the remainder of the body. The extra activity in the head amounted to 4% of the total, and it was found that most of the increase occurred in the first 2 min and was complete by 4 min at the end of the aspiration (Fig. 1).

Discussion

Since ^{113m}In is an effective blood marker *(2)*, changes in the distribution of radioactivity will reflect changes in the distribution of blood. The first aspiration of only 15 ml constitutes a control for the later findings. No patient distress was noted and no significant shift of blood demonstrated. On the second and third occasions, however, the activity ratio of the head to the rest of the body increased markedly after aspiration (Fig. 2). The results indicate that after aspiration of large quantities of fluid from the subdural space there was a rapid shift of approximately 5% of the total blood volume into the head. It is most likely that this blood is retained in the head in the dural sinuses and cerebral veins *(4)*; thus it would be temporarily unavailable to the arterial capillary beds and could result in shock since a sudden loss of blood volume of this order may not be compensable in a dehydrated child.

Assuming a blood volume in this child of 80 ml/kg, the amount of blood required to produce the observed activity changes was calculated (Table 1). On all occasions this was found to be less than the volume of fluid removed, indicating that the blood volume changes are not just simple replacements of aspirate by blood.

Because of the elasticity of the skull in infancy, some decrease in skull volume on aspiration would be expected. Assuming the collapse accounts for the discrepancy between the volume of fluid removed and blood replacing the fluid, then the decrease in skull volume can be calculated as 24 ml on the second aspiration and 29 ml on the third aspiration, accounting for the negligible change in blood volume on the first occasion when only 15 ml of fluid was removed.

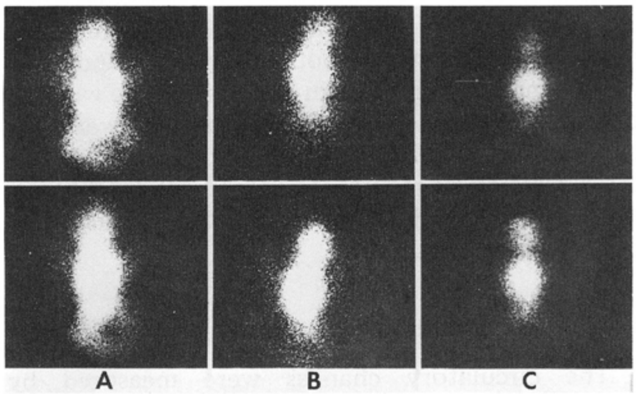

FIG. 2. Whole-body images of infant showing distribution of radionuclide before (top row) and after (bottom row) aspiration after 15 ml (A), 75 ml (B), and 60 ml (C) of subdural fluid was withdrawn.

Conclusions

We conclude that there may be circulatory changes on aspirating subdural hematomas in infants of sufficient magnitude to cause distress and that such changes can be monitored with a suitable radionuclide. The findings support the hypothesis of Martin, et al *(1)* that so-called "brainstem shock" occurring during hematoma aspiration is not due to changing pressure on the brainstem but is ordinary hypovolemic shock due to shift of blood into the intracranial veins. The amount of radioisotope in the subdural fluid was found to be negligible except on the third occasion when successive samples of fluid were found to contain increasing quantities of radioisotope, indicating that fresh bleeding had occurred into the subdural space. This suggests that negative pressure aspiration can induce further bleeding.

References

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