Serial Changes in Focal Hyperemia Associated With Hypertensive Putaminal Hemorrhage

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Seventeen separate xenon-enhanced computed tomographic images were performed in seven patients with hypertensive putaminal hemorrhage. Regional cerebral blood flow maps were then computed and assessed. All patients were categorized as being of good recovery potential, with moderate-sized hematomas, and all were treated conservatively. The regional cerebral blood flow assessments were scheduled within 4 days after, 2 weeks after, and >25 days after the ictus. The initial decrease in hemispheric blood flow ipsilateral to the side of the hematoma was calculated as the ratio of ipsilateral to contralateral hemispheric blood flow and was correlated with the size of the hematoma; that is, the larger the hematoma, the greater the decrease in the ratio of ipsilateral to contralateral hemispheric blood flow. The decrease persisted for 1 month. The mean of the ratio at 2 weeks after onset was 70%, the lowest during follow-up. All cases examined within 4 days after onset demonstrated perihematomatous focal hyperemia, or "luxury perfusion," which accounted for the delayed decrease. The same tissue that had previously shown hyperemia showed decreased regional cerebral blood flow 2 weeks after onset. Our results demonstrate that the luxury perfusion syndrome caused the secondary brain damage even in the cases that were in relatively good condition. The feasibility of treatment can be assessed by considering these results. (Stroke 1988;19:322–325)
we used can be accepted as the alternative method for measuring rCBF (such as positron emission tomography, single photon emission tomography, etc.) have calculated rCBF by using predetermined X = 0.9 for gray matter according to the direct measurement of X by Segawa et al15 using the Xe-CT method with long inhalation. Since other methods for measuring rCBF (such as xenon-enhanced CT) are shown in Table 2. Mean arterial blood pressure in the early period was slightly higher than that during the intermediate and late periods; otherwise, no differences were noted. The mean percentile ratios of hemispheric blood flow for the sides ipsilateral and contralateral to the hematoma (HFI: HFC) were 79% in the early period, 70% in the intermediate period, and 80% in the late period. In the early period, the larger the hematoma, the lower HFI: HFC; the ratio was 58% in Case 2 and 90% in Case 6. HFI: HFC was lowest in cases with larger hematomas and different follow-up intervals. Serial topographic rCBF maps of two cases are shown in Figures 2 and 3.

### Results

Physiologic variables for the patients during Xe-CT are shown in Table 2. Mean arterial blood pressure in the early period was slightly higher than that during the intermediate and late periods; otherwise, no differences were noted. The mean percentile ratios of hemispheric blood flow for the sides ipsilateral and contralateral to the hematoma (HFI: HFC) were 79% in the early period, 70% in the intermediate period, and 80% in the late period. In the early period, the larger the hematoma, the lower HFI: HFC; the ratio was 58% in Case 2 and 90% in Case 6. HFI: HFC was lowest in cases with larger hematomas and different follow-up intervals. Serial topographic rCBF maps of two cases are shown in Figures 2 and 3.

### Discussion

In our study, the Xe-CT method for measuring rCBF was used. The method is efficient because of its excellent spatial resolution. Furthermore, we could easily correlate blood flow in a particular region and the CT appearance of the corresponding tissue by recalling the baseline CT image. However, the short inhalation interval could not supply accurate λ, so we chose λ = 0.9 for gray matter according to the direct measurement of λ by Segawa et al15 using the Xe-CT method with long inhalation. Since other methods for measuring rCBF (such as positron emission tomography, single photon emission tomography, etc.) have calculated rCBF by using predetermined λ, the method we used can be accepted as the alternative method for Xe-CT.

Our study clearly demonstrates that focal hyperemia occurred in the tissue next to the hematoma in patients with HPH. The phenomenon took place very soon after onset and contributed to secondary brain damage during the next 2–3 weeks. This phenomenon is clearly luxury perfusion. We have focused on patients with HPH and cases with hematomas of moderate size because treatment of these cases is controversial.23 We have shown that all cases presented with focal hyperemia and that the hyperemic tissues resulted in ischemic tissues as judged by later rCBF measurements. Thus, luxury perfusion appears responsible for...
later clinical deterioration.\textsuperscript{5,8} Later deterioration was confirmed by our findings that HFI: HFC was lowest 2–3 weeks after onset and this minimum coincided with the maximum intracranial pressure and maximum brain edema.\textsuperscript{6,7} Our study demonstrated that the initial CBF deterioration correlated with the size of the hematoma, as was reported in another longitudinal follow-up study of HIH by Ishii et al\textsuperscript{9} and in an animal model.\textsuperscript{10}

The luxury perfusion syndrome, which was first described by Lassen,\textsuperscript{18} has been observed in ischemic stroke.\textsuperscript{19,20} The phenomenon has been reported in many other cerebral disorders, including nontraumatic intracerebral hemorrhage.\textsuperscript{21,22} However, the occurrence of

\begin{figure}
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\includegraphics[width=\textwidth]{figure1.png}
\caption{Chronologic changes in percentile ratios of mean hemispheric blood flow for sides ipsilateral and contralateral to hematoma (HFI/HFC). Numbers correspond to case numbers in Table 1. Flow map (●) shows perihematomatous focal hyperemia.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Baseline computed tomograms (CT images) (left) and regional cerebral blood flow (rCBF) maps (right) 3 and 16 days after onset of putaminal hemorrhage in Case 3, viewed from above. The 3-day rCBF map demonstrates hematoma as defect of blood flow partly surrounded by area with hyperemia lateral to hematoma (white arrow). The 16-day rCBF map reveals that area with previous hyperemia changed into area with low perfusion (white arrowhead) although plain CT image showed isodensity in corresponding area (black arrowhead).}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Baseline computed tomograms (left) and regional cerebral blood flow maps (right) 3 and 12 days after onset of putaminal hemorrhage in Case 5, viewed from above. This case showed hyperemia in tissue surrounding hematoma followed by late, marked reductions of blood flow in same area. Hemispheric blood flow ipsilateral to hematoma was diffusely reduced.}
\end{figure}
luxury perfusion in HIH remains unclear, because the phenomenon is short-lived and may occur in a limited manner depending on the size and location of the hematoma. If studies were designed to take these conditions into account, results would be more definite, such as those of our study. The clinical significances of the hyperemia is still uncertain. However, as Lassen suggested, because luxury perfusion may be caused by local brain acidosis, acidosis itself may cause tissue injury. Recent investigations suggest that hyperemia opens the blood–brain barrier, and, if surgery is chosen, early evacuation of the hematoma with a less invasive approach may be considered.

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References


Key Words • cerebral hemorrhage • putamen • tomography, x-ray computed • xenon
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