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Characterisation of Supra- and Infratentorial ICP Profiles

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Abstract In pathophysiology and clinical practice, the intracranial pressure (ICP) profiles in the supratentorial and infratentorial compartments are unclear. We know that the pressure within the skull is unevenly distributed, with demonstrated ICP gradients. We recorded and characterised the supra- and infratentorial ICP patterns to understand what drives the transtentorial ICP gradient.

A 70-year-old man was operated on for acute cerebellar infarction. One supratentorial probe and one cerebellar probe were implanted. Both signals were recorded concurrently and analysed off-line. We calculated mean ICP, ICP pulse amplitude, respiratory waves, slow waves and the RAP index of supra- and infratentorial ICP signals. Then, we measured transtentorial difference and performed correlation analysis for every index.

Supratentorial ICP mean was 8.5 mmHg lower than infratentorial ICP, but the difference lessens for higher values. Both signals across the tentorium showed close correlation. Supra- and infratentorial pulse amplitude, respiratory waves and slow waves also showed a high degree of correlation. The compensatory reserve (RAP) showed good correlation. In this case report, we demonstrate that the mean value of ICP is higher in the posterior fossa, with a strong correlation across the tentorium. All other ICP-derived parameters display a symmetrical profile.

Keywords Intracranial pressure • Posterior fossa • Transtentorial gradient • Monitoring • Signal processing

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Introduction

The skull is rostrocaudally segmented by the tentorium into two major compartments: the supratentorial space occupied by the cerebrum and the infratentorial space occupied by the cerebellum. We know that the pressure within the skull is unevenly distributed, with demonstrated intracranial pressure (ICP) gradients [4]. In pathophysiology and clinical practice, little is known about the ICP profiles in the supratentorial and infratentorial compartments. An increase in ICP in the posterior fossa can lead to herniation of the cerebellar tonsils and compression of the brain stem can provoke the patient's death. A supratentorial hydrocephalus can also result from a collapsed fourth ventricle or aqueduct. We tried to characterise the supra- and infratentorial ICP pattern to understand what drives the transtentorial ICP gradient.

Materials and Methods

A 70-year-old man was admitted to our neurosurgery unit with acute cerebellar infarction and infratentorial mass effect. Poor clinical tolerance quickly led to surgical treatment. Before surgery, an ICP probe was inserted into the right frontal region, which is a normal procedure. No external ventricular drainage was placed before resection of the left cerebellar lobe infarction. We used a small craniectomy and, at the end of the surgery, a second ICP probe was left in the posterior fossa. The dura was not sutured and the bone flap was not left in place. After the surgery, the patient was sedated and ventilated in our critical care unit. Both ICP signals were recorded concurrently for 48 h and analysed off-line with ICM+ software. We calculated mean (m), amplitude (amp), respiratory (resp), slow waves and correlation coefficient (R) between the amplitude of the fundamental component (A) and mean pressure (P), RAP, values of the supra- and infratentorial ICP signals [1]. We then performed correlation analysis of the various indices. We also analysed the transtentorial ICP gradient by computing absolute values of supra–infra differences (*d*) among the various ICP-derived indices.

Results

The supra- and infratentorial results are presented in Table 1. ICP was always lower in the supratentorial space. The mean (standard deviation) absolute differences between the supra- and infratentorial space were as follows: dICPm = 8.5 (1.5) mmHg; dICPamp = 0.01 (0.03) mmHg; dICPresp = 0.01 (0.01) mmHg; dICPslow = 0.11 (0.19) mmHg; and dRAP = 0.22 (0.18).

We further analysed the signals to detail the supra-/infratentorial profiles of every parameter. Figure 1 displays a 1-h recording of all ICP-derived indices. We also performed correlation analysis of the supra- and infratentoria and calculated the linear Pearson's coefficient. For the ICPm signal (Fig. 2) very good agreement was found with an ≈10 mmHg offset. For the other signals (Fig. 3), the agreement was also very strong.

Table 1 Mean values of supra- and infratentorial intracranial pressure (ICP) indices during the 48-h recording

	ICPm	ICPamp	ICPresp	ICPslow	RAP
Supra	7.9 ± *5.1*	1.62 ± *0.49*	0.10 ± *0.05*	*0.75* ± *0.9*	0.40 ± *0.39*
Infra	16.4 ± *4.5*	1.43 ± *0.44*	0.09 ± *0.04*	0.65 ± *0.69*	0.37 ± *0.43*

Discussion

Supratentorial ICPm was 8.5 mmHg lower than infratentorial ICP, which is expected because of the physiology; the changes in ICPm across the tentorium also showed close correlation. The supra–infratentorial gradient was reduced for higher ICPm values. Supra- and infratentorial pulse amplitudes showed strong correlation. Slow waves and respiratory waves also showed a high degree of correlation across the tentorium (Fig. 3). The compensatory reserve measured with RAP did not show a perfect match during the whole recording, but correlated well within the physiological range of ICP (Fig. 3).

There is sparse literature on infratentorial ICP. Rosenwasser et al. [3] reports a clinical series suggesting that during the first 12 h the posterior fossa pressure might be 50 % greater than that of the supratentorial space in all patients. Over the next 12 h the supratentorial pressure was 10 and 15 % higher than the posterior fossa pressures in all patients, and after 48 h of monitoring, the pressures had equilibrated. Slavin and Misra also report dynamic changes over time in a small series of patients [5]. Rieger et al. published an experimental study of animal models of supratentorial ICP elevation [2] and demonstrated that infratentorial ICP elevation led to a uniform ICP elevation in the intracranial space without development of a considerable pressure gradient below and above the tentorium. In the low pressure part of the ICP curve, cerebrospinal fluid connected the compartments and contributed to the pressure equilibrium.

Our results are in accordance with those of the published data. During the signal analysis of this case report, we have

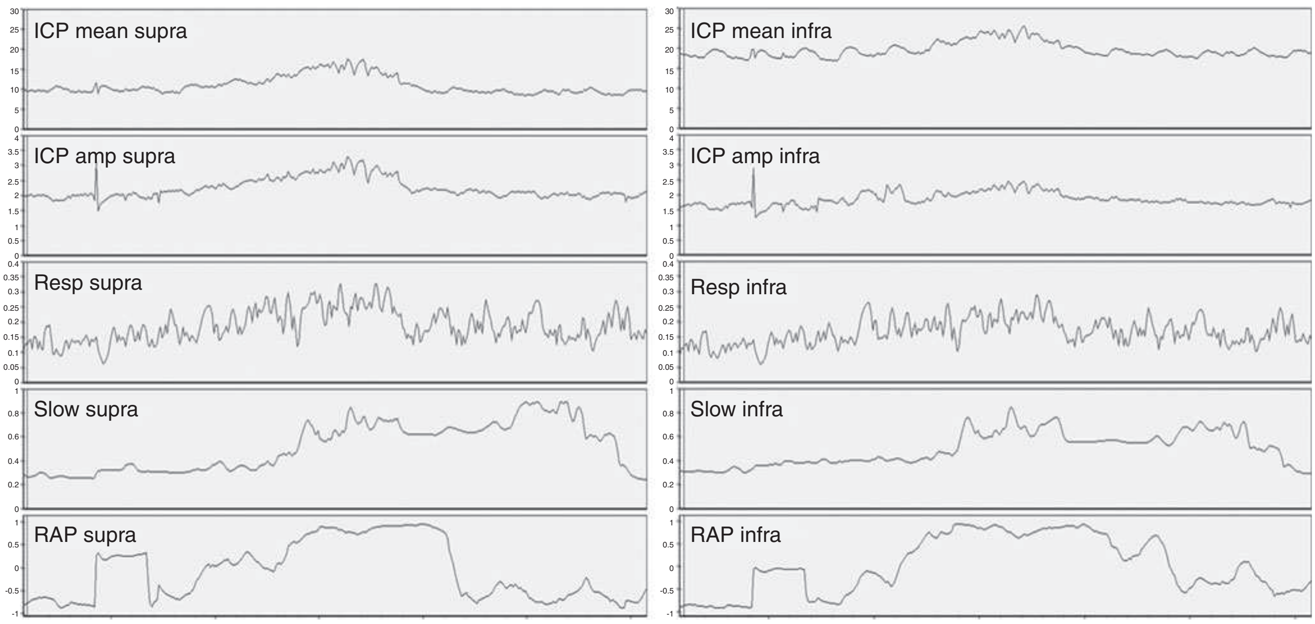

Fig. 1 Example of a 1-h recording of supra- and infratentorial intracranial pressure (ICP) signals. Note the very good agreement along the timeline of the various indices

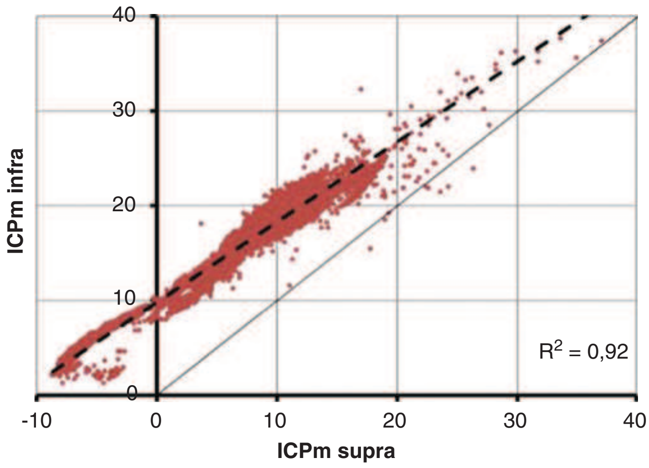

Fig. 2 Correlation between supra- and infratentorial mean ICP. Linear regression line represented b y a *dashed line* with Pearson's coefficient r^2. Symmetry is denoted by a *solid diagonal line*

been very surprised by the strength of correlation between supra- and infratentorial profiles. In this particular case, the posterior fossa was left open, and we thought that the mechanical properties should be altered. Although we found a significant transtentorial difference in terms of mean pressure, supra- and infratentorial ICP profiles were very much in accordance. The mean value of ICP is higher in the posterior fossa, but the difference lessens for higher values of all other ICP-derived parameters, which display the same symmetrical profile. For higher values, the signal seems lower in the posterior fossa.

However, this study deals with only one patient who shows a pathological condition of the posterior fossa. Thus, while surgery restores the physiological state as far as possible, the skull approach and the craniectomy, even if very small, could have led to disturbance of the data. The same applies to the resection of the cerebellar infarction by modifying the volume of the

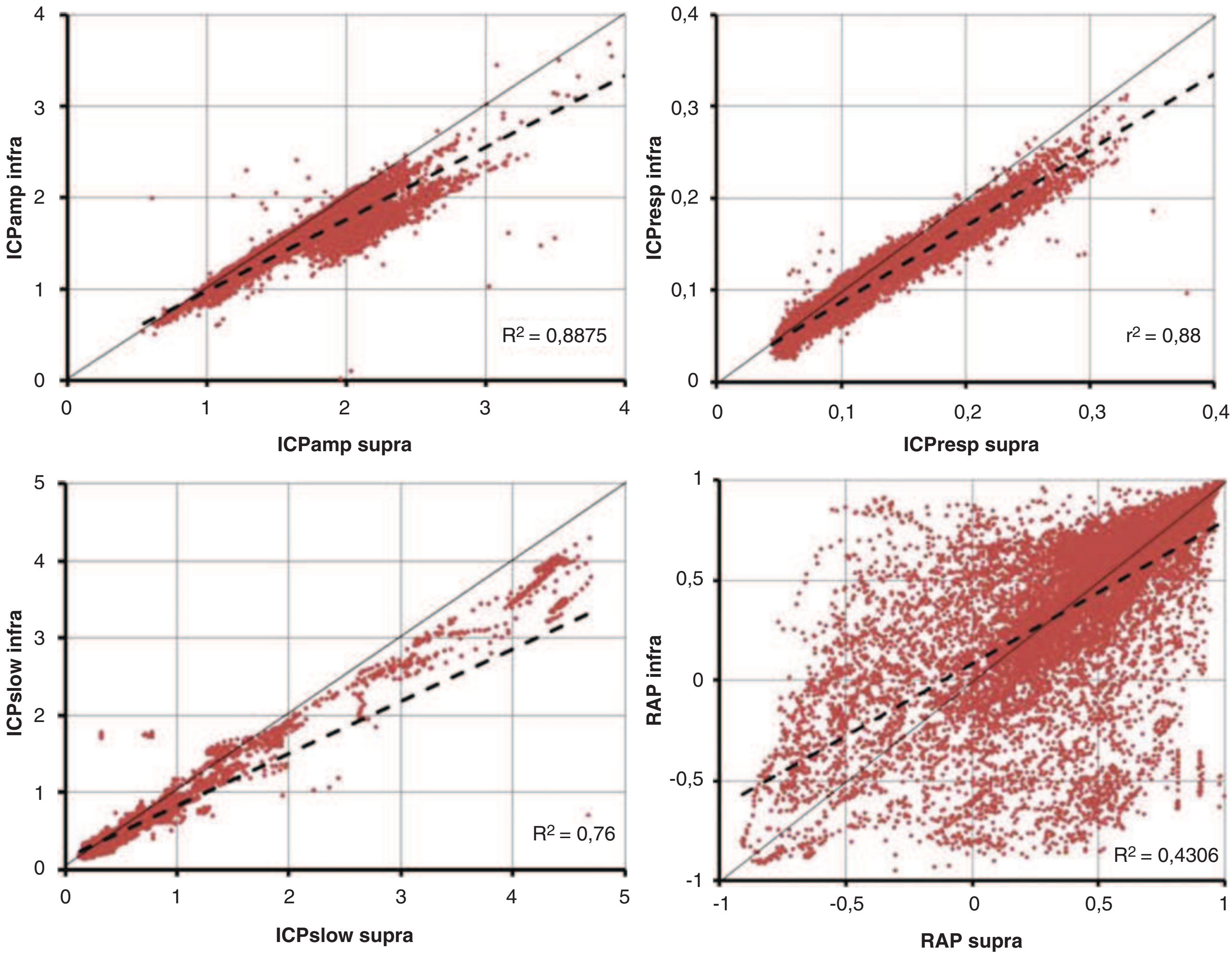

Fig. 3 Correlation between supra- and infratentorial ICP-derived indices: ICP pulse amplitude (*upper left*), respiratory waves (*upper right*), slow waves (*lower left*), RAP index (*lower right*). Linear regression line is represented by a *dashed line* with Pearson's coefficient r^2. Symmetry is denoted by a *solid diagonal line*

infratentorial space. This highlighted the difficulties of routinely monitoring ICP in the cerebellum in a clinical situation. In fact, the placement of any probe in the infratentorial compartment is not as easy and as safe as in supratentorial the compartment and the method of using non-invasive techniques could be of interest in many cases. Zhang evaluated the correlation between increased ICP in supratentorial, infratentorial and transcranial Doppler (TCD) parameters of basal arteries [6]. He concluded that there were intracranial pressure gradients in mass lesions; thus, the probe should be positioned where the mass lesion is situated. To perform non-invasive ICP monitoring using TCD, the basal artery should be chosen instead of the middle cerebral artery, which is usually used. However, we have been unable to detail the supra-infratentorial profiles for every ICP parameter.

Overall, in one recording, ICPm was 8.5 mmHg lower in the cerebrum than in the cerebellum and all the ICP profiles show a high degree of correlation.

Conflict of Interest Statement There is no conflict of interest to declare.

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