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Effect of Cerebral haemodynamics after Cranioplasty using Transcranial Ultrasonogram

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Abstract:
Aim and objective: *The aim and objective of this study is to investigate the effect of cerebral hemodynamics after cranioplasty in decompressive craniectomy patients using pre and postoperative transcranial Doppler sonogram.*
Methods: *This study is a prospective study of two years duration. This study includes total no of 43 patients. All the patients were evaluated by transcranial Doppler sonography before and after cranioplasty.*
Results: *Statistically significant differences between the values before and after cranioplasty were detected in Peak Systolic Volume (PSV) for the Anterior Cerebral Artery (ACA) (P=0.001), in PSV for the Middle Cerebral Artery (MCA) (P=0.001), in Mean Bloodflow Velocity (MV) for the MCA (P=0.005), and in PSV for the Posterior Cerebral artery (PCA) (P=0.004) on the ipsilateral side. There were statistically significant differences between the values before and after cranioplasty in PSV for the PCA (P=0.005), on contralateral side. There were no statistically significant differences between End Diastolic Volume (EDV) of all arteries on both sides (P=0.156for the ACA, P=0.321 for the MCA, and P=0.062 for the PCA on the contralateral side, P=0.681 for the ACA, P=0.879 for the MCA, and P=0.075 for the PCA on the ipsilateral side.*
Conclusion*: Cranioplasty will significantly improve cerebral blood flow both on ipsilateral and contralateral cerebral hemispheres.*
Keywords: *Transcranial Ultrasonogram, cerebral hemodynamics, cranioplasty.*

I. Introduction

Transcranial Doppler sonography provides unique information concerning the velocity, pulsatility, and routes of blood flow through the circle of Willis and vertebrobasilar system, is based on the detection of frequency shifts from insonated red blood cells moving through a small, preselected arterial spatial region, the sample volume. The sample volume, as with all pulsed-wave (range-gated) Doppler devices, is determined by the lateral focusing of the transducer, the duration of the transmitted sound burst (Tb) at a specific pulse repetition rate (PRF), and the duration of the range-gate opening (Ts)[1-3]. Doppler that have a 2-MHz, handheld, pulsed-wave, single-element transducer that can detect Doppler signals at depths of 2.5-15 cm at preselected 5-mm intervals can be used. It is sensitive to Doppler frequencies up to 10 kHz without aliasing and provides adjustable levels of transmitted sound energy between 10 and 100 mW/cm^2.

II. Material And Methods

This Study Effect Of Cerebral Haemodynamics After Cranioplasty Using Transcranial Ultrasonogram is a prospective study done from July 2010 to July 2012.Methyl methacrylate was the material used for cranioplasties of all patients and all cranioplasties were performed under General Anaesthesia. The variables recorded were: age, sex, site, original diagnosis, site of defect, interval between craniectomy and cranioplasty, pre and post operative transcranial Doppler ultrasonogram studies. All the skull defects were hemicranial (involving more than two regions on one side).

III. Inclusion Criteria

All traumatic intracerebral haemorrhages, hypertensive intracerebral haeorrhages.

IV. Exclusion Criteria

Cases with cardiovascular disorder, depressed skull fractures, age less than 16 years. 43 patients were evaluated by transcranial Doppler sonography before and after cranioplasty. The factors that could affect cerebral hemodynamics during transcranial Doppler sonogram such as fatigue, hunger, alteration of arterial blood pressure, were eliminated. All postoperative transcranial Doppler ultrasound studies were performed within 7 to 15 days after cranioplasty.

The patients were examined using VIN BIOTCH SYSTEMS LTD, PROVIEW Doppler sonogram and 2.5 MHz 900 sector viewing V219 transducer through transtemporal window. The cranial defect itself was not used as an examination route. The Doppler spectrum of anterior cerebral artery, middle cerebral artery and posterior cerebral artery was obtained using 300-600 insonation angle with angle correction. We used the lowest level of sample size and wall filter. Aliasing artifacts were eliminated by optimum baseline correction. After the frozen stable waveform was obtained, peak systolic velocity (PSV), end diastolic velocity (EDV), and mean blood flow velocity (MV) of the middle cerebral artery (MCA), the anterior cerebral artery (ACA) and the posterior cerebral artery (PCA) were calculated by cursor pointing. Means, with standard deviations, of PSV, EDV, and MV in all ipsi- and contralateral MCA, ACA and PCA were calculated.

V. Results And Analysis

This study includes total no of 43 patients, out of which 40 were male and 3 were female patients.

All the 43 patients were in between 19 to 60 years of age. The median time interval between cranioplasty and initial surgery is 9 months.43 patients were evaluated by transcranial Doppler sonography before and after cranioplasty. Pre operative ipsilateral PSV,EDV,MV of ACA,MCA and PCA were assessed. The average values of ACA-PSV(77.25), EDV(37.75), MV(50.87), MCA-PSV(83.3) EDV (40.65), MV(54.5) and PCA-PSV(67.8), EDV(36.45), MV(46.7) and is shown in table 1.

Table 1: Preop Ipsilateral Blood Flow Velocities

	PSV	EDV	MV
ACA	77.25	37.75	50.87
MCA	83.3	40.65	54.5
PCA	67.8	36.45	46.7

Pre operative contralateral PSV, EDV, MV of ACA, MCA and PCA were assessed. The average values of ACA-PSV(83.45), EDV(44.5), MV(52.55), MCA-PSV(91.69) EDV(42.5), MV(53.2) and PCA-PSV(78.35), EDV(39.7), MV(51.85) are shown in table 2.

Table 2 : Preop Contralateral Blood Flow Velocities

	PSV	EDV	MV
ACA	83.45	44.5	52.55
MCA	91.695	42.5	53.2
PCA	78.35	39.7	51.8

Post operative ipsilateral PSV,EDV,MV of ACA,MCA and PCA were assessed. The average values of ACA-PSV (90.7), EDV(39.9), MV(56.85), MCA-PSV (97.9) EDV(42.15), MV(60.7) and PCA-PSV (80.5), EDV(32.6), MV(48.6) and are shown in table 3.

Table 3 : Postop Ipsilateral Blood Flow Velocities

	PSV	EDV	MV
ACA	90.7	39.9	56.85
MCA	97.9	42.15	60.7
PCA	80.5	32.6	48.6

Post operative contralateral PSV, EDV, MV of ACA, MCA and PCA were assessed. The average values of ACA PSV(89.65), EDV(39.25), MV(56.1), MCA-PSV(97.6) EDV(45.3), MV(60.7) and PCA-PSV(85.7), EDV(34.5) MV(51.4) and are shown in table 4.

Table 4 : Postop Contralateral Blood Flow Velocities

	PSV	EDV	MV
ACA	89.65	39.25	56.1
MCA	97.6	45.3	60.7
PCA	85.7	34.5	51.4

All post operative ipsilateral blood flow velocities are increased except EDV of PCA. Post operative contralateral blood flow velocities are increased except EDV of ACA and PCA.

All the variables for MCA,ACA and PCA, ipsilateral and contralateral, preoperative and postoperative were taken. The difference was analyzed by the Wilcoxon matched-pairs signed-rank test in SPSS for windows (version 16,2007,IBM,USA). P values lesser than the threshold of 0.05 were considered significant.

Statistically significant differences between the values before and after cranioplasty were detected in PSV for the ACA (P=0.001), in PSV for the MCA (P=0.001), in MV for the MCA (P=0.005), and in PSV for the PCA (P=0.004) on the ipsilateral side. There were statistically significant differences between the values before and after cranioplasty in PSV for the PCA (P=0.005), on contralateral side. There were no statistically significant differences between EDV of all arteries on both sides (P=0.156for the ACA, P=0.321 for the MCA, and P=0.062 for the PCA on the contralateral side, P=0.681 for the ACA, P=0.879 for the MCA, and P=0.075 for the PCA on the ipsilateral side.

VI. Discussion

Common indication for decompressive craniectomies include Traumatic brain injuries following road traffic accidents. In our study 39 patients underwent decompressive craniectomy following traumatic brain injury for road traffic accidents,4 patients underwent decompressive craniectomy following hypertensive gangliocapsular bleed. Meticulous cranioplasty is important for good cosmetic results, as well as long-term protection of brain from external environment. Cerebral blood flow, brain metabolism, as well as neurological status are affected by the outside pressure in patients with skull defects.[4-6.] In our study 8 patients with "syndrome of trephined" reported that they had improved after cranioplasty .Their main complaints of headache, insomnia, mental depression and local discomfort on movement had diminished. Hemiparesis improved in 3 patients. Others remained unchanged after cranioplasty.

Neurological recovery after cranioplasty has attracted attention among neurosurgeons in the last two decades. Some reports emphasized unexpected neurological recovery after cranioplasty.[6-9] The mechanism of neurological recovery after cranioplasty remains unclear to date. Various mechanisms of the relationship between the cranial defect and cranioplasty were suggested and investigated.[4,5,6,8,10.]

Restoration of cerebral hemodynamics as an explanation for neurological recovery after cranioplasty was proposed by Richaud et al in 1985.[5] Hatashita et al studied the effect of craniectomy on the biomechanics of normal brain in animals in 1987.[9] They demonstrated that a large craniectomy causes a decrease of pressure in both the cerebrospinal fluid and the normal brain parenchyma. Transcranial Doppler ultrasonography is a widely accepted non-invasive method to measure the intracranial arterial perfusion rates in adults and children.[11,12] . The advantages of Transcranial ultrasongram include low cost, non-invasiveness and lack of radiation. The changes of cerebral hemodynamics could easily be shown by Transcranial ultrasonogram. In our study the changes in PSV and MV values were statistically significant in the detection of cerebral hemodynamics after cranioplasty but there was no significant change of EDV values, presumably due to stable diastolic cerebral blood flow velocity as a protection mechanism .

Every cranial defect allows transmission of direct atmospheric pressure onto the intracranial contents, especially on the blood vessels. Before cranioplasty the whole vascular structure in both hemispheres was affected in the same manner by atmospheric pressure through the affected area. When the velocities were compared between the contralateral side and the ipsilateral side after cranioplasty, all the velocities in the MCA, the ACA and the PCA were found elevated after cranioplasty.

VII. Conclusion

1. Cranioplasty will significantly improve cerebral blood flow both on ipsilateral and contralateral cerebral hemispheres.
2. Transcranial Doppler ultrasongram is an effective, non-invasive and inexpensive method of detecting changes of cerebral hemodynamics.
3. Neurological improvement after cranioplasty can be explained by improvement of cerebral hemodynamics.

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