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Clinical commentary

Clinical and radiological assessment of cerebral hemodynamics after cranioplasty for decompressive craniectomy – A Clinical study

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ABSTRACT

Objectives: To find the correlation between radiologically proven improvement in cerebral hemodynamics with clinical improvement in patients undergoing cranioplasty.

Material and methods: The study is a prospective observational study of 10 cases, in M S Ramaiah Institute of Neurosciences, involving patients treated by a decompressive craniectomy for intractable intra cranial hypertension either due to trauma or stroke and afterwards underwent cranioplasty.

Results: Of the 10 patients, 70% patients showing significant improvement in motor functions on Barthel index scale, 60% patients showed improvement in speech, mean duration from date of decompressive craniectomy to cranioplasty being 122.4 days. Cerebral perfusion was remarkably better after cranioplasty, as demonstrated decrease in the Pulsatility index on the ipsilateral side of decompression on Trans cranial Doppler (<0.73 mean). This data also favored improved cerebral blood flow and permeability on the CT perfusion with increase in cerebral blood flow (CBF), Cerebral Blood Volume (CBV) and decrease in Time to Peak (TTP) and a positive outcome when correlated with Barthel index with *P*-values of 0.093, 0.017 and 0.001 respectively.

Conclusion: Cranioplasty influences the cerebral hemodynamics after cranioplasty and has a positive correlation on the functional outcome and cerebral blood flow in the MCA territory.

1. Introduction

Decompressive craniectomy has been a vital tool in the neurosurgeon's armamentarium for over a hundred years now. First described by Harvey Cushing in 1905, it is widely used to treat intracranial hypertension secondary to various conditions, most notably trauma and stroke [1,2]. The removal of the bone cover over the brain leaves it vulnerable to a variety of insults, both external and internal. It brings along a major shift in the normal physiology of the brain both directly and indirectly by altering the blood flow dynamics and CSF dynamics. Atmospheric pressure has been blamed for most of these changes and theoretically, cranioplasty should revert back the normal physiology. There are various studies to show the blood flow changes after cranioplasty using Transcranial Doppler (TCD) and ^{133}Xe CT. Case reports and clinical series suggest improvement in cognitive and neurological deficits after cranioplasty. However, the correlation of clinical improvement with radiological evidence of improved blood flow has not been shown before. Also since TCD is highly operator dependent and 133Xe CT is invasive as it uses radioactive material, we have used a combination of TCD and CT perfusion (CTP) to accurately note the changes in cerebral blood flow and correlate with clinical improvement.

1.1. Objective

To find the correlation between radiologically proven improvement in cerebral hemodynamics with clinical improvement in patients undergoing cranioplasty.

2. Methods and materials

After obtaining an adequate ethical clearance we conducted a prospective observational study, involving 10 patients treated by a Decompressive Craniectomy (DC) for intractable intracranial hypertension either due to trauma or stroke and afterward underwent cranioplasty between October 2014 and September 2015.

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Patients both male and female of any age group were included in our study, Patients had to be hemodynamically stable and the brain had to be lax.

Patients who have undergone any other cranial surgery before, allergic to iodinated I.V contrast material, did not consent for surgery or perfusion studies or who had a surgical site infection have been excluded. Patients were admitted on the day before the surgery and evaluated. All patients underwent a standard autologous bone flap cranioplasty under general anesthesia using the bone flap that was cryopreserved or kept in the anterior abdominal wall during DC.

A detailed clinical examination for assessing motor and functional status is done before the cranioplasty, immediately after the cranioplasty, at 6 weeks and 3 months there on. Assessment of functional status was done by Barthel's index. All patients underwent a pre-operative TCD, immediate postoperative TCD, at 6 weeks and 3 months after the surgery. They also underwent a pre-operative CTP scan (SIEMENS, SOMATOM PERSPECTIVE 128 slice scanner) preoperatively and at 6 weeks after the surgery.

Univariate and multivariate analysis was be done using the appropriate statistical methods and SPSS software version 18.0

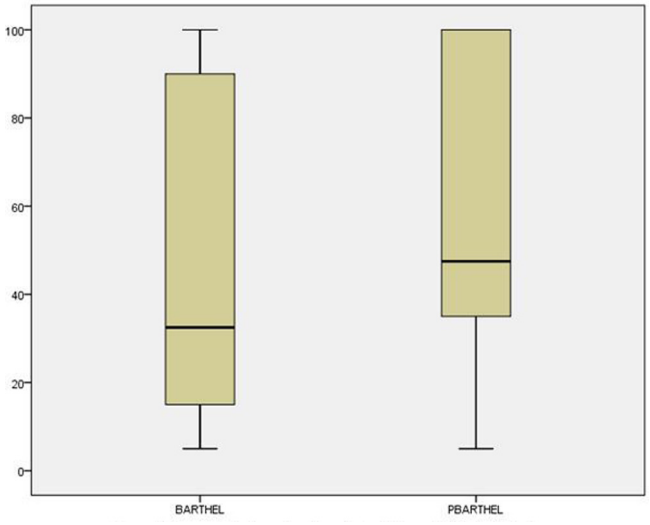

Fig. 1. Pre-cranioplasty and post cranioplasty (6-weeks) Barthel's Index Scores.

3. Results

A total of 10 patients were recruited in this study from the period of October 2014 to September 2015, (Table 1) 5 were operated for trauma, 2 for infarction, and 3 for Cortical Vein Thrombosis (CVT) etiologies.

The time interval between craniectomy and cranioplasty was between 34 days and 210 days with a mean duration of 122.4 days. Barthel Index(BI) scores obtained for the 10 patients were assessed pre-op, 6 weeks showed an increase in the mean BI scores from 47 to 57 ($P = 0.026$) (Fig. 1).

Blood Flow across MCA on the ipsilateral side of DC and MCA vessels contralateral to the side of DC were recorded by a TCD preoperatively and at 6 weeks (Fig. 2). Peak systolic volume (PSV), End Diastolic Volume (EDV), Pulsatility Index (PI), Resistance Index (RI) scores of TCD across the MCA on either side were analyzed preoperatively and at 6 weeks (Table 2).

At the end of 6 weeks, PI which measures the flow across the vessels on TCD showed a significant decrease from 1.2 to 0.73 in the MCA vessels on side of cranioplasty and from 1.15 to 0.54 on the contralateral side of cranioplasty.

When the BI outcome post cranioplasty was correlated with the post op PI using Wilcoxon signed rank test showed a correlation in the improvement of the BI scores and the PI values, $p = 0.023$.

Resistance Index (RI) which represents flow resistance distal to the site of insonation, indicated a marginal decrease from 0.54 to 0.51 in the resistance to blood flow across the MCA vessels on the side of cranioplasty and Resistance Index remained the same at 0.54 in the MCA vessels on the contralateral side of cranioplasty. There was no correlation in post-operative RI values and Barthel's Index ($p = 0.959$).

Table 1
Demographics.

Number of patients	10
Mean time duration for between craniectomy and cranioplasty	122.4 days
Laterality of cranioplasty-Right	3
Left	7
Indication of decompressive craniectomy	
Trauma	5
Infarction	2
Cortical venous thrombosis	3

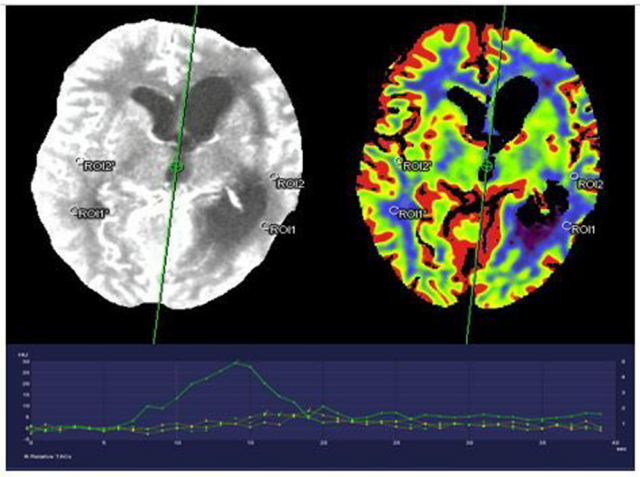

Fig. 2. CT-Perfusion scan-Region of Interest (ROI) in the territory of MCA selected and CBF, CBV and TTP Parameters were obtained from the graph in case 8.

All 10 patients also underwent CTP brain scans preoperatively and after cranioplasty at 6 weeks.

Cerebral blood flow (CBF), Cerebral Blood Volume (CBV), Time to Peak (TTP) were measured from data obtained using the SIEMENS, Somaris/5 Syngo CT workplace 2013A software (Fig. 2). CBF, CBV were measured across a consistent Region Of Interest (ROI) in the territory of MCA vessels on the side of Decompressive Craniectomy and Contralateral side of DC.

Mean CBF across the Region of Interest in the MCA territory on the side of cranioplasty increased at the 6 weeks post cranioplasty (52.86 ml/min/100 g) as compared to CBF pre-cranioplasty (48.28 ml/min/100 g) with a P value of <0.003. Also, Mean CBF in the MCA territory on the contralateral side of cranioplasty showed an increase in the values (54.84 ml/min/100 g) at 6 weeks post cranioplasty (51.99 ml/min/100 g). Pre-cranioplasty and post cranioplasty values of Time To Peak (TTP) were analyzed by plotting on a scattered graph, values of which clustered around the trend line indicating a positive trend. TTP improved significantly on both ipsilateral and contralateral sides of cranioplasty at 6 weeks compared to preoperative values, from 59.05 s to 51.53 s ipsilateral side and 66.15–61.26 s contralateral side, post cranioplasty (Fig. 3).

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