Trabajo de investigación

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Lumbar cerebrospinal fluid drainage in severe head injury

Carlos Pineda Márquez MD,* Jorge E Herrera MD, PhD,† J Fortino Chávez Carbajal MD,‡ Héctor Zirahuén Monroy C MD,* Martha B Reséndiz Villalpando MD,* Ma. del Carmen García L RN*

RESUMEN

Objetivo. Determinar la utilidad clínica y seguridad del drenaje de líquido cefalorraquídeo (LCR) en pacientes no quirúrgicos con traumatismo craneoencefálico severo (TCES).

Diseño. Estudio clínico prospectivo.

Lugar. Una UCI de un hospital de segundo nivel de Morelia, Mich. (México).

Pacientes. Treinta y tres pacientes no quirúrgicos con TCES, no monitorizados con presión intracraneana y sin desviación de la línea media.

Intervenciones. Se realizó drenaje del LCR mediante una punción lumbar a intervalos de 24 o 72 horas hasta obtener una presión subdural lo más cercana posible a 20 cm de agua.

Mediciones y resultados principales. Hubo una correlación negativa entre la hipertensión subdural y la Escala de Coma de Glasgow (ECG) al ingreso, con la Escala Pronóstica de Glasgow (EPG) al egreso. Cuarenta y cinco por ciento de los pacientes fueron egresados en buenas condiciones (EPG 4-5).

Conclusión. El drenaje descompresivo lumbar de LCR es un procedimiento útil y seguro en el tratamiento de los pacientes con TCES no quirúrgico.

Palabras clave: Líquido cefalorraquídeo, drenaje lumbar, presión subdural, traumatismo craneoencefálico severo, hemorragia subaracnoidea.

SUMMARY

Objective. *To determine the clinical usefulness and safety of lumbar cerebrospinal fluid drainage (CSF) in nonsurgical patients with severe head injury (SHI).*

Design. *A prospective clinical study.*

Setting. *An ICU of a second level hospital of Morelia, Mich. (México).*

Patients. *Thirty three nonsurgical SHI patients, non-monitored with intracranial pressure and without shift of midline.*

Interventions. *At intervals of 24 or 72 hours a lumbar CSF drainage was performed and CSF was drawn as much as to bring a subdural pressure the closest possible to 20 cm of water.*

Measurements and main results. *There was a negative correlation between subdural hypertension and the Glasgow Coma Scale (GCS) score at admission with the Glasgow Outcome Scale GOS) score at discharge. Forty five percent of patients were discharged in good condition (GOS 4-5).*

Conclusion. *Decompressive drainage of lumbar CSF is a useful and safe procedure as treatment of nonsurgical patients with SHI.*

Key words: *Cerebrospinal fluid, lumbar drainage, subdural pressure, severe head injury, subarachnoid hemorrhage.*

Severe head injury (SHI)) is a significant cause of morbidity and mortality in patients with a continuos rise of intracranial pressure;[1] hence, intracranial hypertension treatment is of paramount importance in this kind of patients.[1,2] In SHI patients intracranial hypertension treatment is focused to improve cerebral perfusion pressure.[2] Standard neurointensive measures include mild hyperventilation ($PaCO_2$ near 35 torr), mannitol, sedation and barbiturates, as needed, and ventricular drainage of cerebrospinal fluid.[3] Ischemic brain damage

* Unidad de Terapia Intensiva del Hospital «Dr. Miguel Silva», Morelia Mich., México.

† Sección de Terapia Experimental, Departamento de Farmacología y Toxicología CINVESTAV-IPN, México, D.F.

‡ Departamento de Investigación Biomédica del Hospital General Dr. «Miguel Silva». Facultad de Medicina «Dr. Ignacio Chávez» de la Universidad Michoacana de San Nicolás de Hidalgo.

may be potentially increased by cerebral vasoconstriction due to the use of hyperventilation particularly if a decrease of cerebral perfusion pressure is present.[4] Osmotic diuretics may produce hypovolemia[5] and barbiturates lead to reduction of cardiac output and cerebral perfusion pressure.[6] These factors may be considered in the early management of SHI patients, since a decrease of cerebral blood flow has been reported.[7]

CSF drainage through ventriculostomy has proved to be a better therapeutic advantage than other procedures.[8] However this method requires high and expensive technology,[9] which is seldom available in developing countries. CSF lumbar drainage is assumed to be contraindicated in SHI patients because of the risk to produce transtentorial hernation.[10,11] Still, there is little information about the potentially risk of intracranial herniation in lumbar CSF drainage with intracranial hypertension (IH) secondary to SHI with no shift of midline and/or extracerebral mass. Recently, has been reported the use of lumbar CSF drainage on pediatric patients with SHI and IH refractory to conventional treatment.[12]

Because there are evidences that SHI patients often develop intracranial hypertension which is associated with severe neurologic deficits and poor prognosis, we decide to conduct a prospective study in order to determine the therapeutic usefulness and clinical safety of CSF lumbar drainage with the purpose to improve the cerebral perfusion in nonsurgical patients without shift of midline.

PATIENTS AND METHODS

Thirty three subsequent patients admitted to the intensive care unit (ICU) with SHI without shift of midline and a Glasgow Coma Scale (GCS) score ≤ 8 were enrolled in this study. Patients with central nervous system drug intoxication and blood hypotension were excluded. The study was approved by the Institutional Ethics and Research Committee of our hospital and written informed consent was obtained from a family member.

Once the patients were assisted with mechanical ventilation and stabilized within the ICU, lumbar puncture was attempted to carry out every 24 hours, using a fine spinal needle (24 or 25 gauge), between L3 and L4. CSF pressure was measured by a manual rachimanometer. Opening pressures on every time were recorded and CSF was drawn as much as to bring subdural pressure the closest possible to 20 cm H_2O. After maintaining opening pressure $\leq$ 20 cm H_2O, subsequent lumbar punctures were scheduled every 72 hours if neurologic deficit was observed to identify further increase in subdural pressure.

Samples of CSF were analyzed for cultures, cells, proteins and glucose. All the patients received standard medical treatment. Central venous pressure was kept between 4 and 8 mm Hg using isotonic crystalloid fluids and red blood cell transfusions were given to achieve hematocrit closest to 30%; no patient received dextrose solutions. When subdural pressure was greater than 20 cm H_2O mannitol 0.5 g/kg/4 h was administered. Sedation was obtained with IV midazolam boluses of 0.05 mg/kg/h to allow adequate ventilation and neuromuscular blockade was avoided. All the patients received 12 g/day of magnesium sulfate in IV continuos infusion. It was maintained $PaCO_2$ between 30 and 35 torr and SaO_2 over 90%; positive end expiratory pressure was not used. When a hemorrhagic CSF was observed, nimodipine 60 mg every 4 hours was administered during 15 days through a nasogastric tube. Hyperthermia was treated with indomethacin, hyperglycemia was controlled with regular insulin and phenytoin was used for the treatment of patients with seizures and/or skull fractures. No patient received prophylactic antibiotics. A progressive diet in calories and volume was set up as much to achieve 1,800 Kcal in 3 liters of water. At discharge from the ICU, all the patients were assessed with Glasgow Outcome Scale (GOS) score.

Statistical analysis. Parametric (mean $\pm$ SEM) and nonparametric statistics was applied according to the type of variables. Logistic correlation and Spearman's correlation coefficients were calculated between Glasgow Coma Scale score and CSF subdural pressure; Fisher's exact test was used for the analysis of frequencies between different events and GOS. The Wilcoxon Rank Sum test and the Kruskal-Wallis test was used to compare the subdural pressures. A $p < 0.05$ was considered statistically significant.

RESULTS

Patient demographics are presented in *table I*. The mean age of the patients was 27.6 years (range 16-62). There were 28 males (under 40 years) and five females. The time of onset of SHI before to admission to the ICU was 26.2 $\pm$ 4.4 hours (range 1-120). The patients had a median GSC of 6. Cerebral CT scans were performed in 31 patients

Table I. Demographia data at admission and discharge.

Age (yrs)	27.6	±	2.0 (16-62)
Sex	28M		5F
time of onset of SHI in hours	26.2	±	4.4 (1-120)
Glasgow Coma Scale (GCS) score	6.0 median		(3-8)
Computed Cerebral Tomography (CCT)			
Cerebral Edema	31/33		(94%)
Subarachnoid hemorrhage (SHA)	32/33		(97%)
Damage of cerebral parenchyma	22/33		(67%)
[a]Other findings (SFx, IVH, PNE)	15/33		(45%)
Subdural pressure (cm of water): 1st day	26.0	±	2.2 (8-60)
2nd day	22.4	±	1.9 (5-38)
3rd day	23.5	±	1.8 (8-45)
Hyperglycemia: > 180 mg/dL	14/33		(42%)
Low blood pressure: < 90/60 mm Hg	18/33		(55%)
Hypoxia: SaO_2 < 90%	11/33		(33%)
Tracheostomy	11/33		(33%)
Gastrostomy	6/33		(18%)
Glasgow Outcome Scale (GOS) score			
GOS 1 = Death	8/33		(24.2%)
GOS 2 = Vegetative Life	3/33		(09.1%)
GOS 3 = Dependet disability	7/33		(21.2%)
GOS 4 = Indepenedet disability	11/33		(33.3%)
GOS 5 = Complete Recovery	4/33		(12.1%)

[a]: SFx = skull fracture, IVH = intraventricular hemorrhage, PNE = pneumoencephalus.

Table II. Sample distribution as GCS and GOS.

GCS	GOS 1	GOS 2	GOS 3	GOS 4	GOS 5	Sub total
GCS 3-4	3	1	2	1	0	7
GCS 5-6	1	2	3	4	0	10
GCS 7-8	4	0	2	6	4	16
Totals	8	3	7	11	4	33

Abreviations: GCS = Glasgow Coma Scale, GOS = Glasgow Outcome Scale (at discharge), GOS 1 = death; GOS 2 = vegetative life; GOS 3 = dependet disability; GOS 4 = independent disability; and GOS 5 = complete recovery. The number of patients is placed in each grid.

(94%) with the following findings: cerebral edema (94%), subarachnoid hemorrhage (97%) and damage of the cerebral parenchyma (67%). Subdural pressure was 26 ± 2.2, 22.4 ± 1.9 and 23.5 ± 1.8 cm of water at the first, second and third day of ICU stay, respectively. Hyperglycemia was present in 14 patients (42%), low blood pressure in 18 (55%) and SaO_2 below 90% in 11 (33%). Tracheostomy and gastrostomy were performed in 11 (33%) and six (18%) patients, respectively. The overall mortality rate was 24.2% (n = 8). The values of GOS were: 1 (death) 24.2% (n = 8), 2 (vegetative life) 9.1% (n = 3), 3 dependent disability 21.2% (n = 7), 4 independent disability 33% (n = 11) and 5 (complete recovery) 12.1% (n = 4). ICU stay was 9.7 ± 5.4 days (range 3-23). Intratecal puncture was performed through time with less frequency (i.e on 25/33 cases at the third ICU day). It was unsuccessful in two times and no patient had neuroinfection or transtentorial herniation. Mean

subdural pressure decreases to 20 cm of water only after the third ICU day, and subsequently it remained between 15.5 and 18.8 cm of water. Headache was present in one case, which was satisfactorily treated with a nonnarcotic analgesic.

There was a non significant correlation between GCS and GOS in most of the sample size *(table II)*, and nor there was an evident relationship between clinical variables or between cerebral CT scans findings and GOS itself *(table III)*. A non significant correlation was found between the time of admission to the hospital/ICU and GOS 2 *(figure 1)*. Initial subdural pressure correlated significantly with the final subdural pressure *(figure 2)* as well as between GCS and subdural pressures during the first three days of follow-up (figure 3).

When we try to frame a prognosis index (PI) of the clinical course of SHI patients complementary to GOS, involving the most discriminating variables obtained, a greater coincidence was observed between admission and discharge clinical status *(table IV)*, resulting in an index that maintained a greater correlation with other traditional parameters *(table V)*; the most poor PI was 8; it was observed in three nonsurvivors patients (GOS 1, mortality rate of 100%). The critical PI was located between 3 and 4, i.e. all the pa-

Table III. Ocurrence of other discriminating variables related with GOS.

Variable:	Damage in parenchyma n	%	Others (on CCT)[a] n	%	Hyperglycemia n	%	Low blood pressure n	%
GOS 1 (n = 8)	7	87.5	5	62.5	4	50.0	6	75.0
GOS 2 (n = 3)	1	33.3	0	0.0	2	66.7	3	100.0
GOS 3 (n = 7)	6	85.7	4	57.1	2	28.6	6	85.7
GOS 4 (n = 11)	6	54.5	4	36.4	5	45.4	2	18.2
GOS 5 (n = 4)	2	50.0	2	50.0	1	25.0	1	25.0
Total (n = 33)	22	66.7	15	45.4	14	42.4	18	54.5

Table IV. Overall association of most discriminating variables related within a Prognosis Index (PI).

Discriminating variables	Factor	GOS 1 n = 8	GOS 2 n = 3	GOS 3 n = 7	GOS 4 n = 11	GOS 5 n = 4
Subdural pressure: 21 - 25 cm water	(1)	2	1	2	3	0
Subdural pressure: ≥ 26 cm water	(2)	12	4	4	4	6
GCS = 6	(1)[a]	0	0	2	3	0
GCS ≤ 5	(2)[a]	8	6	6	4	0
TOSHI (24 < 48) h	(1)	4	0	2	8	0
TOSHI > 48 h	(2)	6	0	4	0	0
Damage in cerebral parenchyma on CCT	(1)	7	1	6	6	2
Low blood pressure (< 90/60) mmHg	(1)	6	3	6	2	1
Hyperglycemia (> 180) mg/dL	(1)	4	2	2	5	1
Overall PI (average)		6.13	5.67	4.86	3.18	2.5

GOS = Glasgow Outcome Scale, CCT = Computed cerebral tomography. GOS 1 = death, GOS 2 = vegetative life; GOS 3 = dependet disability, GOS 4 = independet disability; and GOS 5 = complete recovery GCS = Glasgow Coma Scale (at admission). Time of onset of SHI prior to admission to the ICU.
a : Means that the found cases are multiplied by a factor of (1) or (2), according to the variable magnitude. Values are converted within the table, e.g.: for GOS = 1 when GCS ≤ 5, four cases of two points for each were found (therefore 4 x 2 = 8)

Table V. Correlations between PI and other variables (Sperman's correlation).

Variables	GCS	GOS	TOSHI
PI	-0.78 p < 0.001	-0.78 p < 0.001	0.23 N/S
GCS		0.23 N/S	0.14 N/S
GOS			-0.52 p< 0.01

PI = Prognosis Indicator. GCS = Glasgow Coma Scale.
GOS = Glasgow Outcome Scale.
TOSHI = Time of onset of SHI prior to admission to the ICU

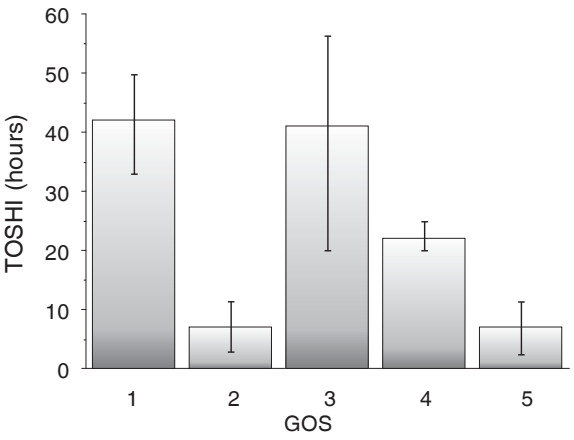

Figure 1. *Figure demonstrates the relationship between the severity of neurologic deficit evaluated through the Glasgow Outcome Scale score (x-axis) and the time of onset of disease before to admission to the ICU (y-axis). The early presentation of the patients to hospital is associated with better outcome.*

tients with GOS 1 and GOS 2 had a PI ≤ 4, whereas all the patients with GOS 4 had a PI ≤ 3.

DISCUSSION

Since the opening of the intensive care unit in the Hospital General «Dr. Miguel Silva» of Morelia in 1988 and until the beginning of the present study in 1994, SHI treated without lumbar drainage had a mortality rate of 45% in a total of 220 patients, which represented 17% of assistance demand (unpublished data). The factors associated with this mortality rate appear to be as follows: a) considerable delay in hospitalization and hemodynamic-respiratory stabilization of the patients; b) and an absence of intracranial pressure measurement and adequate manipulation of measures involved in cerebral perfusion pressure.

Ventriculostomy is widely accepted as a treatment of choice. However because this procedure is not available in our hospital, we were forced to explore other possible choices, such a lumbar puncture.

Intratecal pressure measurement with a fine spinal needle is not a substitution of intracranial pressure measurements through ventriculostomy,

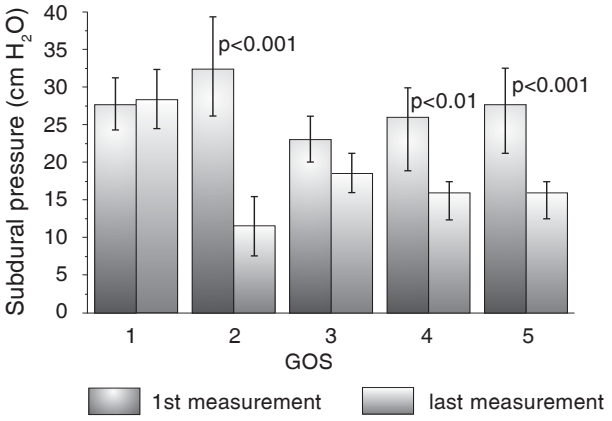

Figure 2. *Comparison between the first (solid bars) and the last (hatched bars) subdural pressure (mean ± SEM) in patients with severe head injury. The significant differences are related with GOS.*

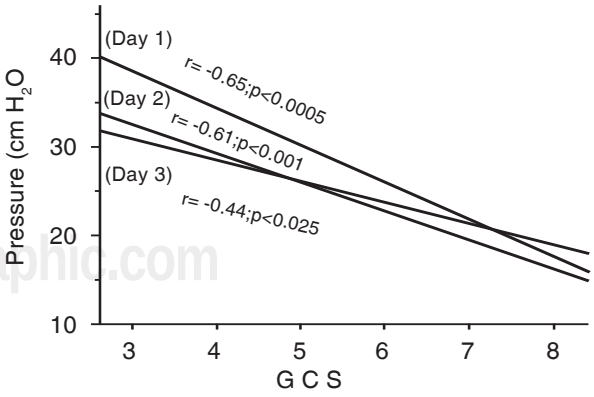

Figure 3. *Negative correlation between the Glasgow Coma Scale score and the subdural pressure in 33 patients with severe head injury. The progressive decrease of the subdural pressure and the increase of GCS occurred in a linear fashion. The three linear regressions belong to the first three days of treatment.*

but it seems that this therapeutic maneuver decrease the mortality according to present study. On the other hand, a negative correlation was observed between admission GCS and increased subdural pressure at 72 hospital hour very similar to values obtained through ventriculostomy,[13] which allows us to assume that this procedure might be utilized in those places where such technology is not available.

In the medical literature, it is difficult to find reports on the analysis of SHI prognosis which do not include intracranial pressure measurement. However, in a retrospective trial performed in Uppsala, Sweden, the authors compared SHI prognosis before and after being equipped with neurologic intensive care units (NICUs), in which 52% of patients admitted to the neurointensive care unit with a GCS score ≤ 8 showed «good recovery» in contrast to 15% which received noninvasive treatment.[3] In addition, the authors noted that continuos intracranial pressure monitoring was performed on 46% of patients in the NICU and no patient was treated outside of this. In a survey undertaken on U.S. revealed that 40% of 1128 neurosurgeons interviewed utilized ICP monitoring techniques on those patients having penetrating SHI with GCS score between 6 and 8.[14]

In 1994 Visvanathan et al reported 29 patients with nonsurgical SHI, who received medical management (sedation, hyperventilation and mannitol), obtaining a mortality rate of 55% and adequate recovery in 24% (GOS 4-5).[15] These data are similar to the ones obtained by us during 1988-1993, when neither lumbar puncture nor subarachnoid pressure measurement was being carried out.

With lumbar puncture, our adverse results (death and vegetative state) were 33%, similar with those trials in which intracranial pressure measurement was routinely carried out by either ventriculostomy or with subdural screw. Although these analyzed reports result from mixed medical-surgical populations the mortality rate is high: 41% reported by Genarelly;[16] 50% in patients over 20 years and 25% under 20 years (Alberico);[17] 31% (Warme) and 29% Rosner.[2,3] The differences might lie in what a «good prognosis» is considered to be (independent disabled and complete recovery, GOS 4-5), which was 45% in our study and with a 21% dependently disabled (GOS 3), which may seem elevated, but the patient follow-up was done up to discharge from the ICU, once that systemic and neurologic conditions were stabilized; therefore, these patients are likely to have overstepped GOS 4 or GOS 5.

Subarachnoid hemorrhage (SAH) was detected in all our patients at the time of lumbar puncture and in 97% of the CT scans performed. This is an important finding since recent studies have shown that it represents an adverse prognosis factor.[18] According to a report from the NIH Traumatic Coma Data Bank of the U.S. National Health Care Centers, the presence of SAH raised twofold the mortality rate in all neurosurgical centers and it has a prognosis value on intracranial hypertension.[19,20] Some researchers have speculated that traumatic SHA might be associated with cerebral arterial spasm secondary to a rupture of aneurysms.[21,23] In this regard nimodipine has shown to have some utility.[24]

Another important prognosis factor for avoiding secondary damage is hyperglycemia, which had a discriminating value in our study. Lam formerly assessed blood glucose levels in 169 patients with different degrees of SHI. He found than blood glucose levels were higher (> 200 mg/dL) in patients with poor outcome.[25] Michaud reported that hyperglycemia above 250 mg/dL linked up with a poor prognosis in 54 patients under 16 years.[26] Steroids have never shown any utility, since their gluconeogenic effect rises blood glucose levels.[27]

The adverse prognosis value of low blood pressure and hypoxemia have been widely recognized.[28] In our study, only low blood pressure had a discriminating value for establishing our PI, and this was due to the fact that hypoxemia occurred unfrequently.

Lumbar puncture and subdural pressure measurements combined with logistic analysis of most discriminating variables played a key role to obtain our PI *(tables IV and V)*, which may be individually applied to patients with similar characteristics (i.e. nonsurgical SHI without shift of midline and GCS score ≤ 8), simple to be carried out, since only whole numbers are used to obtain it and accessible to health centers equipped with computed cerebral tomography. In our population, the procedure was safe and no patient developed neuroinfection or bacterial growth of de CSF samples; this complications have been reported with the use of indwelling subdural catheters. While intermittent lumbar puncture presents some technical problems with the intubated patients and with the intravascular catheters, our experience is that if the position of the patients is changed carefully and the sedation is

good, the hazardous potential is minimal, and the assumptive therapeutic effect surpasses the potential risk. In the present study only one patient suffered strong headache.

On the basis of the results obtained in this small sample of patients with SHI and GCS score ≤ 8, we can conclude that lumbar puncture is a useful alternative and safe procedure to measure subdural pressure in this kind of patients. Nevertheless, these results support the need to make a comparative study between lumbar puncture and ventriculostomy.

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Address request for reprints to:
Dr. Carlos Pineda Márquez
Unidad de Terapia Intensiva
Hospital General «Dr. Miguel Silva»
Isidro Huarte y Samuel Ramos S/N (Centro)
C.P. 58000, Morelia, Mich, México.
Phone (435) 156838, Fax 5120503.