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Validation of a monitoring matrix for patients with brain injuries

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ABSTRACT

Background: Brain injury is a leading cause of death and disabilities worldwide. The severity of brain damage is of course related to the primary injury. Secondary brain insults are the most powerful determinants of outcome from severe head injury. To improve the outcome, it needs to be well detected to be controlled. The detection of these factors can be difficult among numerous data. The objective of this work was to validate a monitoring matrix to help this screening. We hypothesise that a monitoring matrix will improve the detection rate of factors linked to secondary brain injury (SBI).
Method: We conducted a single-center prospective observational simulation study. We designed a monitoring matrix compiling all the brain insults, intracranial data (ICP, CCP, PtiO2) and systemic data (PaCO2, PaO2, temperature, natremia, hemoglobin). Each caregiver had to analyze the same simulated data with a standard monitoring sheet and with the monitoring matrix. We then compared the detection rate of SBI factors.
Results: 25 caregivers analyzed a total of 265 matrixes. The monitoring matrix had a sensitivity of 96.5% and a specificity of 99.9% versus 69.9% and 67.8% respectively for the standard monitoring sheet. The detection rate was significantly higher with the monitoring matrix (96.5%) versus the standard monitoring sheet (69.9%), regardless of the caregiver's status. It is also improved among nurses, regardless of their seniority.
Conclusion: The use of this monitoring matrix is simple and inexpensive. The monitoring matrix improves significantly the detection rate of factors linked to secondary brain injury. It also provides homogenization of the detection rate among the physicians and nurses regardless of their experience. Nurses becoming as qualified as physicians, allows earlier detection and therefore a faster treatment.

Introduction

Brain injury is a leading cause of death and disabilities worldwide whatever the etiology (traumatic, stroke, intrapenchymal hemorrhage, subarachnoid hemorrhage). Two periods are distinguished: primary and secondary brain injury. Primary brain injury is the physical damage to the parenchyma, due to shearing and compression. The secondary brain injury is the result of a complex process, following and worsening the primary brain injury in the ensuing hours and days. These secondary brain Injury (SBI) can be intracranial and extracranial (systemic brain insult). Intracranial brain insults include cerebral edema, hematomas, hydrocephalus, intracranial hypertension, metabolic derangement, excitotoxicity, infection and seizures [1,2]. Systemic brain insults are mainly ischemic [1,3], such as : hypotension (systolic blood pressure [SBP] < 90 mmHg), hypertension (SBP > 160mmHG), hypoxemia (PaO2 < 60 mmHg), hypocapnia (PaCO2 < 35 mmHg), hypercapnia (PaCO2 > 45 mmHg), anemia (Hemoglobin < 10 g/dl or hematocrit <0.30), hyponatremia (serum sodium < 135 mmol/L), hypoglycemia (blood sugar <4.6 mmol/l), fever (temperature > 38 °C), hypothermia (temperature < 35.5 °C). Early treatment limits ischemic cerebral lesions and thus improves prognosis [4–7]. The detection of all of this factors can be difficult for the clinician. A hemodynamic matrix has already been successfully used by Fabrice Vallée for septic shock [8]. We created a monitoring matrix to facilitate the detection of secondary brain insults. The main objective of this work was to determine if the monitoring matrix improved the detection rate of secondary brain injury.

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Methods

Study design

We carried out a single-center prospective simulated observational study at the intensive care unit (ICU) of the Military Hospital Sainte Anne in Toulon, (France). The ICU accommodates about 700 patients per year of whom 45% with severe brain injury**.**

Monitoring matrix creation

We designed a monitoring matrix for patients with brain injury which includes the factors linked to secondary brain injury. We compiled intracranial data: intracranial Pressure (ICP), cerebral perfusion pressure (CPP), brain tissue oxygen concentration (PtiO2) and systemic data (PaCO2, PaO2, temperature, natremia, hemoglobin) (Fig. 1).

Glycemia was excluded because we monitor this parameter every one or two hours with a dedicated insulin therapy protocol to maintain blood glucose between 8 and 10 mmol/L. The monitoring of pupils was not retained because pupillary abnormalities (anisocoria, non-reactive mydriasis . . .) are well known and do not pose detection problems.

Realization of the simulations

The aim of this study was to determine the detection rate during the monitoring of the factors linked to SBI. We hypothesise that a monitoring matrix will improve the detection rate versus a standard monitoring sheet. Our secondary aim was to show that a monitoring matrix can reduce detection differences caused by the experience difference of the physicians or nurses.

The monitoring matrix was tested on simulated values, created by the investigators, no data was obtained from real patient records.

The investigators simulated 2 days of surveillance of 22 patients with 6 data records per day corresponding to the different hours of records data in the day (2a.m, 6a.m, 10a.m, 2p.m, 6p.m and 10p.m), with no notion of aggravation or improvement of the patients. These different data records have been reported on the monitoring matrix and the standard monitoring.

Each participant analyzed the simulated monitoring records of the day 1 and 2, each time with the standard monitoring protocol, then later in the day with the monitoring matrix (Fig. 1), the numbers of abnormalities were variable at the discretion of the investigators but identical between the standard monitoring and the monitoring matrix. The participants were asked to pick up the factors linked to SBI and say if these values were normal or abnormal. The values considered normal were: ICP < 20 mmHg, CPP 50–70 mmHg, PtiO2 > 20 mmHg, PaCO2 34–38 mmHg, PaO2 > 80 mmHg, Temperature 36–37,5 °C, Natremia 140–145 mmol/L, Hemoglobin >8 g/dL. It corresponds to the initial objectives for patients with acute brain injury in our ICU. The standard monitoring protocol of our critical care unit was a sheet of paper with all the general monitoring (pulse oximetry, end-tidal CO2, arterial blood pressure, central venous pressure, systemic temperature, urine output, arterial blood gases, ventilation parameters, all the drugs given time and dose) and the specific monitoring (ICP, CPP, Pti02). The participants were all the caregivers who were working from 8 a.m. to 7 p.m. during two weeks. We collected the following data from each participant: status (attending physician, resident, nurse, student nurse), seniority in the department, number of abnormalities detected, number of undetected abnormalities, number of normal values, number of values considered as normal, time required for analysis.

The data were collected and analyzed by a resident and an attending physician. They have not participated in the test.

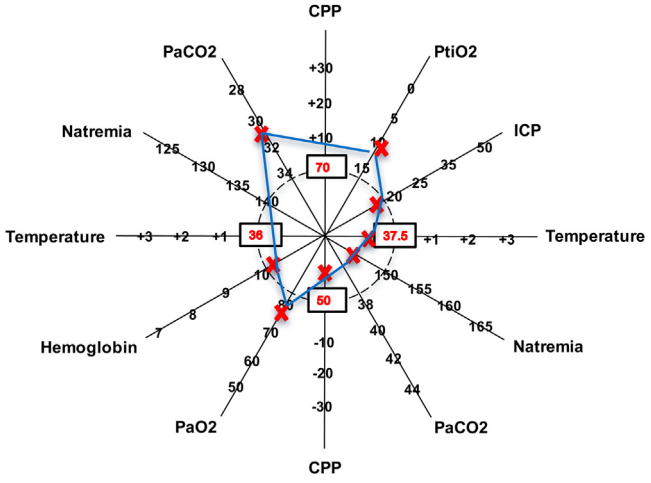

Fig. 1. Monitoring matrix.

Statistical analysis

All statistical analyses were performed with XLSTAT, version (Addinsoft). Nominal variables are reported as number and proportions (%). For all the results expressed in percentages, we give in brackets the numerators and denominators. The values for sensitivity (ratio between True positive / true positive + false negative) and specificity (true negative / true negative + false positive) as well as the values for Positive predictive value (true positive / true positive + false positive) and Negative predictive value (true negative / true negative + false negative) are obtained from pooling all available results.

Results

Twenty-five caregivers (3 attending physicians, 5 residents, 14 nurses and 3 student nurses) were enrolled to analyze the standard monitoring records, then the monitoring matrix. (Fig. 1)

A total of 265 simulated records were analyzed, with an average of 10 simulated records per participant.

To detect factors linked to SBI, the monitoring matrix had a sensitivity of 96.5% (891/923) and a specificity of 99.9% (916/917) versus 69.9% (645/923) and 67.8% (811/1197) respectively for the standard monitoring records. The monitoring matrix had a positive and negative predictive value of 99.9% (891/892) and 96.6% (916/948) versus 62.6% (645/1031) and 74.5% (811/1089) for the standard monitoring.

The detection rate of abnormalities (abnormal value of PPC, ICP, PtiO2, temperature, natremia, PaCO2, PaO2, and Hemoglobin) was significantly higher with the use of the monitoring matrix versus the standard monitoring records 96.5% (891 abnormalities detected/923 abnormalities simulated) versus 69.9% (645/923), in addition there was no difference between physicians and nurses (all experience) in the detection rate of factors linked to SBI when they used the monitoring matrix 97.6% (123/126) versus 98.3% (454/462) (Fig. 2). The detection rate is also improved among nurses and this regardless of their seniority (Fig. 3), the inexperienced nurses (seniority < 1 year in the ICU) had a detection rate of 98.8% (85/86) with the monitoring matrix versus 62.8% (54/86) with the standard record, the detection rate was 95.2% (80/84) for the experienced nurses (seniority of 1–2 years in the ICU) and 99% (289/292) for the very experienced nurses (more than 2 years in the ICU) with the monitoring matrix versus 78.6% (66/84) and 76.4% (223/292) respectively with the standard records.

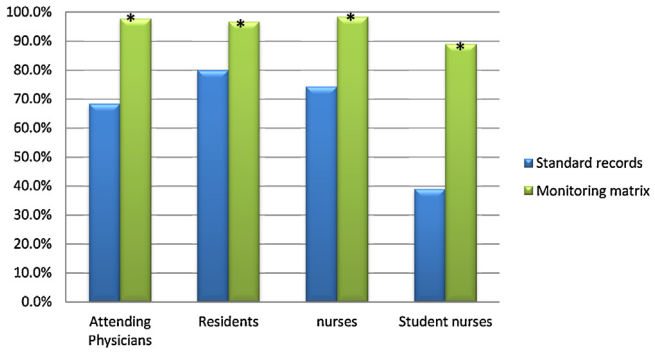

Fig. 2. Detection rate by caregiver status.

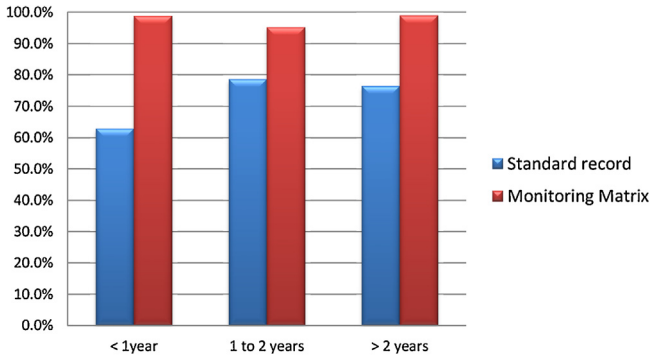

Fig. 3. Detection rate among nurses based on seniority.

Discussion

The detection of all the factors linked to SBI can be difficult, in our ICU the experienced attending physicians in neuro critical care had a detection rate of these factors of only 70% with our standard record, this can be explained by the fact that the specific data are diluted in the set of all parameters. This means therefore that potentially 30% of the abnormalities are not seen and thus not adjusted with a potential impact on the patient's outcome.

The use of this visual monitoring matrix is simple and inexpensive. It improves the detection of factors linked to SBI by caregivers whatever their status or seniority. In our work, the monitoring matrix improves significantly the detection rate of factors linked to SBI and therefore favors their treatment. For example, it helps the clinician to correct these factors and decide to ventilate, treat anemia, dysnatremia, before using other treatment strategies such as more sedation, CT, barbiturates, craniectomy . . . Bulger et al. has shown in a retrospective study that there was considerable variation in the managment of severely head-injured patients across centers in the United States and that "a rapid and aggressive" management strategy is associated to a decreased mortality rate [9]. It also provides homogenization of the detection rate among the physicians and nurses regardless of their experience. Nurses become as effective as physicians to detect these factors linked to SBI. This allows earlier detection and therefore a faster treatment of the factors linked to SBI by the bedside ICU nurse, who is most often the first person who identifies abnormalities and warns the physician. The introduction of the monitoring matrix was simple and easyly accepted by the nursing staff. The nurses' membership allowed to continue the use of this tool after the study period. The monitoring matrix concept has revealed a way to involve all the medical and paramedical staff in neuro critical care. We are conscious that it is not the only way, but in our ICU, it helped us to detect and treat rapidly the factor linked to SBI.

Our goal was not to provide a monitoring matrix with which it is no longer necessary to know these parameters and their normal values, but rather to provide a tool that promotes their exhaustive and earlier detection. We think this monitoring matrix can help especially in ICU with little experience of neuro critical care. Improvements are possible, in particular, computerization with automatic collection.

However, we understand the limitations of our study, as follows: a) being a simulation study with no real patient, and a prerequisite for implementation in our ICU, b) there is no evidence that better detection of factors linked to SBI improves patients outcome, c) important factor linked to SBI was excluded of our monitoring matrix such as glycemia but this monitoring matrix is flexible to the choices of each medical staff and d) being only a monocentric study, it was assessed only in an ICU experienced in neuro critical care.

Conclusion

This study is preliminary. It only introduces a visual monitoring matrix, without studying the potential impact on patients outcome. However, this monitoring matrix significantly increases the detection rate of factors linked to SBI which could therefore allow an earlier treatment. The creation of a multiparametric monitoring tool such as this monitoring matrix has enabled us to find a way to educate and involve the nursing team.

Improvements are possible, in particular, computerization with automatic collection. Further clinical studies are needed to assess the impact on patients outcome.

Authors' contributions

M.Cardinale wrote the paper and managed the data collection. P.Esnault, E.d'Aranda, E.Meaudre and G.Iacroix managed the data collection and governance of the study. All the authors have contributed to the writing of the manuscript and have approved the final manuscript. M.Cardinale and G.Lacroix conceived the study and are its guarantor.

Disclaimer

The authors declare that they have no competing interests.
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The publication has not been published elsewhere.

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