Impact of a neurointensivist on outcomes in patients with head trauma treated in a neurosciences intensive care unit

Panayiotis N. Varelas, M.D., Ph.D., Dan Eastwood, M.S., Hyun J. Yun, Ph.D., Marianna V. Spanaki, M.D., Ph.D., Lotfi Hacein Bey, M.D., Christos Kessaris, M.D., and Thomas A. Gennarelli, M.D.

Departments of Neurology, Neurosurgery, Biostatistics, and Radiology, Medical College of Wisconsin, Milwaukee, Wisconsin

Object. The aim of this study was to evaluate the impact of a newly appointed neurointensivist on outcomes in head-injured patients in the neurological/neurosurgical intensive care unit (NICU).

Methods. The mortality rate, length of stay (LOS), and discharge disposition of all patients with head trauma who had been admitted to a 10-bed tertiary care university hospital NICU were compared between two 19-month periods, before and after the appointment of a neurointensivist. Data regarding these patients were collected using the hospital database and the University HealthSystem Consortium (UHC) database. Samples of medical records were reviewed for Glasgow Coma Scale (GCS) score documentation.

The authors analyzed data pertaining to 328 patients before and 264 after the neurointensivist’s appointment. The unadjusted mean in-hospital mortality rate increased 1.1% in the after period, but this increase was significantly lower compared with the UHC-based expected increase of 8.1% in the mortality rate during the same period (p < 0.0001). The unadjusted mean mortality rate in the NICU decreased from 13.4 to 12.9% (relative mortality rate reduction 4%) and the mean NICU LOS increased from 3.1 to 3.6 days (relative NICU LOS increase 16%), both nonsignificantly. A 51% reduction in the NICU-associated mortality rate (p = 0.01), a 12% shorter hospital LOS (p = 0.026), and 57% greater odds of being discharged to home or to rehabilitation (p = 0.009) were found in the after period in multivariate models after controlling for baseline differences between the two time periods. Better documentation of the GCS score by the NICU team was also found in the after period (from 60.4 to 82%, p = 0.02).

Conclusions. The institution of a neurointensivist-led team model had an independent, positive impact on patient outcomes, including a lower NICU-associated mortality rate and hospital LOS, improved disposition, and better chart documentation.

Key Words • head trauma • documentation • intensive care unit • neurological outcome • neurosurgical outcome

Staffing ICUs with critical care physicians, or intensivists, is known to improve patient outcomes. Full-time employment of an intensivist has been associated with improved outcomes in pediatric patients and reduced mortality rates in adult patients following abdominal aortic aneurysm repair. There are few data regarding the influence of an intensivist on the neurological and neurosurgical population, however. In patients with ICH, the introduction of an NICU team decreased mortality rates, shortened the hospital LOS, lowered total costs of care, and led to better disposition at discharge. In another study with a similar population of patients with ICH, the presence of a full-time neurointensivist was associated with a lower mortality rate, but the LOS was longer in the NICU than in the general ICU. Most recently, investigators in two large studies reported that the presence of a neurocritical care team was an independent predictor of a decreased mortality rate in the NICU and associated with decreased hospital and NICU LOS.

In this study, we evaluated the impact that a newly appointed neurointensivist had on outcomes in patients with head trauma who had been admitted to an NICU.

Clinical Material and Methods

We retrospectively reviewed data pertaining to all NICU trauma admissions during two consecutive 19-month periods, before and after the arrival of a neurointensivist: be-
between February 1999 and August 2000, and between September 2000 and March 2002. Our facility is a tertiary care hospital with a Level 1 trauma center covering the eastern Wisconsin and northern Illinois population. The NICU is a 10-bed unit contiguous with the neurosurgical, neurological, and spinal care ward services. Trauma admissions to the NICU are limited to patients with isolated head or spinal trauma or those with polytrauma, that is, only those with major neurological injury and minor systemic injuries; patients suffering from polytrauma characterized by minor neurological involvement are regularly admitted to the surgical ICU. We included in this analysis only patients with head trauma (cerebral contusions, subdural or epidural hematoma, traumatic subarachnoid hemorrhage, or depressed skull fractures) and excluded those with isolated spinal cord injuries. Although the neurointensivist was involved in the treatment of all patients with central nervous system trauma and occasionally was consulted in other ICUs, for uniformity purposes we did not include patients cared for in any unit other than the NICU.

We used the hospital Affinity database (QuadraMed Co., San Rafael, CA) to retrieve patient records and prospectively entered information. Some of the early patient data (from 1999) were part of an older hospital database (Allegra) and thus were retrieved manually and entered into the current database. We then linked this database to the UHC database to determine the expected mortality rate and expected LOS. The UHC uses a combination of the Refined Diagnosis-Related Group Rouper and the Sachs Complication Profiler in conjunction with data on specific patient characteristics (age, sex, urgency of admission, and payer class) to construct risk adjustment regression models that predict LOS, hospital costs, and inpatient mortality rate (http://www.uhc.edu). We decided not to evaluate the expected and observed cost of staying in the NICU or hospital because of a change in the way billing was conducted in the middle of the after period, which made comparisons difficult to interpret.

The two periods in the NICU practice were not significantly different in terms of the medical or nursing staff, except for the presence of the neurointensivist-led team. The same admitting physicians were employed during both periods, and we had no reason to believe that they changed their practices during the second period. The house staff, predominantly neurosurgical residents, did not change significantly; neither did the nursing staff change during the two periods, with a mean NICU nursing staff experience of approximately 11 years.

Several changes in the NICU ensued during the after period at a patient-care and administrative level, as proposed by the neurointensivist and implemented through collaborative teamwork. New, more intensive methods of monitoring were introduced, such as transcranial Doppler ultrasonography, jugular bulb oxygen saturation, and regional cerebral oxygen saturation with infrared-transcranial or parenchymal catheter monitoring technology, resulting in faster responses to emerging problems.

Treatment protocols for traumatic brain injury were developed based on best clinical practices, providing standardized management while at the same time allowing flexibility with respect to patient differences through continuous feedback among the NICU staff. The neurointensivist, who was also appointed medical director of the NICU, installed a continuously supervised resident ICU team: a 2nd-year neurosurgical resident was assigned exclusively to the NICU during the first 6 months of the academic year and monthly rotating residents from neurology, general surgery, emergency, and anesthesiology during the entire year (two–three residents during the first 6 months and six–seven residents during the second 6 months of the academic year); therefore, depending on the schedule, one or more residents were always available in the NICU. In addition, the neurointensivist held weekly meetings with the nursing supervisors and educational conferences for the house staff (daily teaching sessions, workload permitting) and nursing staff (periodically). Triage issue resolution also differed. In the before period, triage was performed daily by the chief resident based on the admitting attending’s instructions. In the after period, final decisions regarding admission and discharge were still made by the primary attending, but triage was facilitated by the neurointensivist through direct attending-to-attending communication and more expeditious resolution of residual issues that had previously kept the patients in the NICU. All these changes promoted a multidisciplinary, collaborative decision-making approach in the NICU to treating patients with head trauma.

We evaluated important outcome variables in the two periods, including the mortality rate and LOS in the NICU, post-NICU LOS, total hospital LOS, documentation of important prognostic variables in the medical records, and disposition of the patients at discharge. Documentation was evaluated by examining 50 randomly selected records in the before and 50 in the after period. We extracted records from the same season of the year—that is, the first 50 serial records of patients with head trauma, beginning on the 1st day of January 2000 for the before period and on the 1st day of January 2001 for the after period—and determined the presence of an important prognostic variable, most notably the GCS score, which would have been optimally documented within the first 48 hours of admission in every patient with head trauma.

Statistical analysis was performed using the t-test for numerical variables, and the chi-square test (or the Fisher exact test) for nominal variables. For multivariate analysis, we excluded repeated admissions to the NICU. For outcomes containing censored data (mortality rate and LOS), Cox proportional hazards models were built. In the analyses of LOS, time was censored at the time of death in patients who had died. Models were developed starting with the significant univariate predictors, checking the proportional hazards assumption, and then adding variables one at a time to the multivariate model, with a significance entry level of 0.05. For the construction of the models, admission sources were grouped as physician referral, transfer from another hospital, emergency department, and other. The presence of a nonproportional hazard was also evaluated in case the hazard rate was not constant over time. In these models, a hazard ratio less than 1 implied a lower mortality rate; a ratio greater than 1 increased the likelihood of being discharged, implying a shorter LOS.

For disposition outcomes, a nominal logistic regression model was constructed. Three separate disposition outcomes were simultaneously examined: home or rehabilitation center compared with skilled nursing facility compared with death. The model included admission source, expected mortality rate and LOS, expected mortality rate according to the expected LOS, patient age, and period before or after...
the neurointensivist’s appointment. For the multiple comparison testing inherent in conducting pairwise comparisons of three distinct outcomes, a Bonferroni multiple testing adjustment was used to control for a familywise error rate of 0.05; this adjustment for multiple testing led to a probability value less than 0.017 for a statistically significant variable. Analysis was performed using commercially available statistical software (SAS, version 8.2; SAS Institute, Cary, NC).

Results

Three hundred twenty-eight patients (30% of all NICU admissions) with head trauma were admitted to the NICU before the neurointensivist’s appointment, and 264 (21% of all NICU admissions) after. Table 1 displays the demographics for the two periods. During both periods the majority of patients were admitted to the neurosurgery service. There were fewer otolaryngology/facial trauma and more neurological cases in the after period. These patients had presented with either major facial fractures and minimal cerebral injury or head trauma accompanied by seizure or other change in mental status, but no surgical lesion. Patients in the after period were significantly more sick, based on UHC-based expected mortality and LOS (Fig. 1).

Table 2 features the results of a univariate analysis of the outcomes in the two periods. The mean total in-hospital mortality rate increased by 1.1% (from 15.2 to 16.3%, 95% CI = 5.4 to 8, a relative increase of 7.2%) in the after period. Nonetheless, this observed increase was significantly less than the much greater mean expected mortality rate increase of 8.1% (from 7.27 to 15.35%, p < 0.0001; Table 1) in the after period. The mean hospital LOS also increased by 0.27 days (95% CI = 1.02 to 1.56, a relative increase of 3.7%) in the after period. This observed increase was no different from the greater mean expected hospital LOS of 1.4 days (from 8 to 9.4 days, p = 0.067; Table 1). Thus, the hospital LOS, but not the in-hospital mortality rate, can be explained by what was expected to happen based on the UHC data. Most patients died in the NICU. The NICU-associated mortality rate had a nonsignificant relative decrease of 4% and the LOS, a nonsignificant relative increase of 16%. There was no significant difference in the disposition of the 499 survivors, except that more patients were discharged to an intermediate-care facility in the after period. More patients with a higher UHC-based expected mortality rate were discharged to home in the after period (Fig. 1). Following discharge, fewer survivors were readmitted to the hospital in the after period, but this value was not statistically significant. In 48 medical records in the before period and all 50 in the after period, GCS score data were available for extraction. Documentation of GCS score was significantly improved in the after period.

Tables 3 and 4 feature results of the multivariate analysis adjusted for baseline covariates. A combined total of 44 repeated admissions to the NICU and admissions with an unknown expected LOS or other missing data were excluded from the Cox proportional hazards analysis; thus, 309 patients in the before and 239 patients in the after period were included in this analysis. The Cox proportional hazard remained constant during the two periods. Adjusting for the UHC-based expected mortality rate and LOS, there was a statistically significant 51% reduction in death (p = 0.01, Model I) and a 16% greater likelihood of NICU discharge (representing a shorter LOS; p = 0.14, Model IV) in the after period when a neurointensivist was present, compared with the before period. The hospital LOS was also 12% shorter in the after period (p = 0.026, Model V). In these models, the admission source was also a significant predictor of the NICU-associated mortality rate and LOS. Four hundred ten patients were included in the nominal logistic regression analysis: 231 in the before period and 179 in the after period, excluding all patients with unknown/nonspecific discharges and patients leaving against medical advice. There was an overall significant difference in the discharge dispositions in the after period after adjusting for UHC-based expected mortality rate, UHC-based expected LOS, and source of admission (overall p = 0.0197, Model VI). In pairwise comparisons, the odds of being discharged to home or a rehabilitation facility as opposed to being dead were 1.57 times greater in the after period than in the before period (p = 0.0063). For other pairwise comparisons, the odds of being discharged to home or a rehabilitation facility as opposed to a skilled nursing facility as opposed to being dead were not statistically significant (p > 0.017). Patient age also independently predicted the disposition in the multivariate logistic model (overall p = 0.0006). Controlling for the effects of all other variables, the odds of being discharged to a skilled nursing facility as opposed to being dead increased by 3% for every year of patient age increase (p < 0.0002). No such age effect was found for the other disposition comparisons—both for being discharged to home or a rehabilitation facility as opposed to being dead, and for being discharged to a skilled nursing facility as opposed to being dead.
Discussion

Our study data show improvement in several outcome variables following the appointment of a neurointensivist in the NICU despite the fact that patients in the after period were more sick than those in the before period. This result can be explained by hospital and interdepartmental policy changes, including the presence of the neurointensivist, which allowed more sick patients—that is, those suffering from polytrauma characterized by major injuries involving the head—to be admitted to the NICU instead of the surgical ICU in the after period. In a univariate analysis, the NICU-associated mortality rate was decreased by 0.5% (relative reduction of 4%; Table 2), despite a higher mean expected in-hospital mortality rate in the after period. This improvement was not limited to the NICU, but extended to the total in-hospital mortality rate. The observed slight increase in the latter (relative observed increase of 7.2%) was significantly less than the expected increase based on UHC data from the two periods (relative expected increase of 110%, \( p < 0.0001 \); Table 1). The decreased NICU-associated mortality rate was not attributable to the dying patients’ dispositions out of the NICU; note that the mortality rate for those on the ward did not increase significantly (Tables 2–4; Model II) and that although there was no NICU palliative policy, patients were permitted to die in the familiar environment of the NICU (a request frequently made by families). The NICU and hospital LOS were nonsignificantly increased in the after period, but this was an expected finding based on UHC data because the patients in the after period were more sick. Dispositions of the patients were quite comparable between the two periods, and more patients in the after period were discharged to an intermediate-care facility, although the numbers are small. After adjusting for the UHC-based expected mortality rate, expected LOS, and admission source, we found a significantly reduced mortality rate of 51% in patients in the NICU and a 40% reduction in the in-hospital mortality rate in the after period, compared with the before period. Similar models for LOS showed a nonsignificant 16% greater likelihood for NICU discharge and a significant 12% greater likelihood for hospital discharge in the after period, compared with the before period. After adjusting for the difference in the UHC-based expected mortality rate and hospital LOS, 57% more patients were discharged to home instead of dying in the

![Figure 1](image_url)
after period, compared with the before period (Model VI). Moreover, in the after period there was no increase in the disposition to a skilled nursing facility compared with disposition to home or dying. More aging patients were discharged to a skilled nursing facility than to home in these multivariate models. Our findings in this subpopulation with head trauma are comparable with previously published data from the same hospital regarding all NICU admissions, most of which were nontraumatic cases.

In these models, however, the neurointensivist’s impact was greater during the first 3 days of the NICU admission and the NICU LOS was shorter. In the present study, the mortality rate was uniformly decreased during the entire NICU admission.

Additionally, documentation of an important prognostic variable in the medical records was almost three times better in the after period (Table 2). Documentation facilitates communication among physicians, frequently serves as the basis for research and education, helps to authenticate diagnoses as well as the necessity for or the propriety of interventions, defends against medical negligence allegations, and serves as the basis for billing consequent to patient care. In this regard, the quality of documentation reflects the quality of delivered care.

The degree to which the improvement in documentation was attributable to the neurointensivist, either directly or indirectly through peer pressure, is unclear, because it might also have resulted from general measures adopted by the hospital. Furthermore, the extent to which this effort to improve documentation affected reimbursement or the quality and quantity of resident teaching is beyond the scope of this paper.

The improved outcomes in this study may have several possible explanations and may not be the result of a single person’s direct contribution to patient care. Individual neurointensivist’s critical care skills, more extensive experience in the NICU, and direct uninterrupted involvement with patient treatment all contribute to better and more ef-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before NI</th>
<th>After NI</th>
<th>p Value</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NICU LOS in days (mean ± SD)</td>
<td>3.1 ± 4.3</td>
<td>3.6 ± 4.2</td>
<td>0.16</td>
<td>1.08 (0.7–1.6)</td>
</tr>
<tr>
<td>hospital LOS in days (mean ± SD)</td>
<td>7.3 ± 8</td>
<td>7.6 ± 7.9</td>
<td>0.68</td>
<td>0.95 (0.6–1.5)</td>
</tr>
<tr>
<td>mortality rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total in-hospital</td>
<td>50 (15.2)</td>
<td>43 (16.3)</td>
<td>0.7</td>
<td>1.9 (0.7–5.4)</td>
</tr>
<tr>
<td>NICU</td>
<td>44 (13.4)</td>
<td>34 (12.9)</td>
<td>0.84</td>
<td>0.95 (0.6–1.5)</td>
</tr>
<tr>
<td>ward</td>
<td>6 (1.8)</td>
<td>9 (3.4)</td>
<td>0.22</td>
<td>1.9 (0.7–5.4)</td>
</tr>
<tr>
<td>disposition at discharge</td>
<td></td>
<td></td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>home</td>
<td>156 (56.1)</td>
<td>120 (43)</td>
<td>0.7</td>
<td>1.7 (0.7–1.5)</td>
</tr>
<tr>
<td>general hospital population</td>
<td>8 (2.9)</td>
<td>19 (6.8)</td>
<td>0.49</td>
<td>1.54 (0.4–5.2)</td>
</tr>
<tr>
<td>skilled nursing facility</td>
<td>22 (7.9)</td>
<td>19 (6.8)</td>
<td>0.7</td>
<td>0.89 (0.5–1.7)</td>
</tr>
<tr>
<td>intermediate-care facility</td>
<td>1 (0.4)</td>
<td>6 (2.7)</td>
<td>0.04</td>
<td>0.13 (0.01–1)</td>
</tr>
<tr>
<td>rehabilitation center</td>
<td>3 (1.1)</td>
<td>5 (2.3)</td>
<td>0.3</td>
<td>0.5 (0.1–2)</td>
</tr>
<tr>
<td>30-day readmission**</td>
<td>22 (8.1)</td>
<td>9 (4.1)</td>
<td>0.07</td>
<td>2.1 (0.93–4.6)</td>
</tr>
<tr>
<td>documentation††</td>
<td>29 (66.4)</td>
<td>41 (82)</td>
<td>0.02</td>
<td>2.9 (1.2–7.5)</td>
</tr>
</tbody>
</table>

* Odds ratios and probability values represent pairwise comparisons.
† Discharged to home compared with general hospital population.
‡ Discharged to home compared with skilled nursing facility.
§ Discharged to home compared with intermediate-care facility.
‖ Discharged to home compared with rehabilitation center.
** Survivors with available data: 272 in the before period and 221 in the after period.
†† Available medical records: 48 in the before period and 50 in the after period.

TABLE 3
Results of multivariate regression models adjusted for UHC-based expected mortality rate and LOS*

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent</th>
<th>Independent</th>
<th>Hazard Ratio (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>mortality in NICU</td>
<td>after period</td>
<td>0.49 (0.29–0.85)</td>
<td>0.0106</td>
</tr>
<tr>
<td></td>
<td>mortality in NICU</td>
<td>admission source†</td>
<td>NCM</td>
<td>0.009</td>
</tr>
<tr>
<td>II</td>
<td>mortality after NICU‡</td>
<td>after period</td>
<td>1.8 (0.55–5.9)</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>total in-hospital mortality‡</td>
<td>after period</td>
<td>0.6 (0.38–0.99)</td>
<td>0.048</td>
</tr>
<tr>
<td>III</td>
<td>total in-hospital mortality‡</td>
<td>admission source†</td>
<td>NCM</td>
<td>0.03</td>
</tr>
<tr>
<td>IV</td>
<td>LOS in NICU</td>
<td>after period</td>
<td>1.16 (1.02–1.4)</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>LOS in NICU</td>
<td>admission source†</td>
<td>NCM</td>
<td>0.005</td>
</tr>
<tr>
<td>V</td>
<td>hospital LOS‡</td>
<td>after period</td>
<td>1.12 (1.03–1.5)</td>
<td>0.026</td>
</tr>
</tbody>
</table>

* Models were constructed using a Cox proportional hazards analysis. Abbreviation: NCM = not clinically meaningful.
† Multiple degrees-of-freedom tests show the overall significance of this factor. Multiple comparison tests showing the details of factor level comparisons are not included here.
‡ Model includes the same variables as those in the mortality in NICU model.
although these factors are difficult to apply in numerous previous trials. The UHC regression or Mortality Probability Modeling Outcomes in that series were significantly better in To or in specific NICU environments with better neurological surveillance and more aggressive treatment protocols. Note, however, that those factors may have been applied in numerous previous trials. In summary, the neurointensivist-led team approach and the transition from an open unit model to a semiclosed one were associated with improvements in several outcomes in patients with head trauma. Additional studies are warranted to determine the impact of this model of care at more than one institution, evaluate the specific contribution of healthcare personnel or specific treatment protocols, estimate NICU and hospital cost savings, and assess long-term outcomes.

Conclusions

In summary, the neurointensivist-led team approach and the transition from an open unit model to a semiclosed one were associated with improvements in several outcomes in patients with head trauma. Additional studies are warranted to determine the impact of this model of care at more than one institution, evaluate the specific contribution of healthcare personnel or specific treatment protocols, estimate NICU and hospital cost savings, and assess long-term outcomes.

Acknowledgements

We thank the nursing and ancillary NICU staff for their dedication to patient care and their significant contribution to this paper’s results.

References

1. Anonymous: Guidelines for the management of severe head inju-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Independent</th>
<th>Odds Ratio (95% CI)</th>
<th>p Value (df)</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall before/after differences for discharge disposition†</td>
<td></td>
<td>0.0197 (2)</td>
<td></td>
</tr>
<tr>
<td>home vs death after period</td>
<td></td>
<td>1.57 (1.14–2.17)</td>
<td></td>
</tr>
<tr>
<td>home vs nursing home after period</td>
<td></td>
<td>1.27 (0.90–1.80)</td>
<td></td>
</tr>
<tr>
<td>nursing home vs death after period</td>
<td></td>
<td>1.23 (0.83–1.84)</td>
<td></td>
</tr>
<tr>
<td>overall effect of age‡</td>
<td></td>
<td>0.0006 (2)</td>
<td></td>
</tr>
<tr>
<td>death vs home age</td>
<td></td>
<td>1.02 (1.00–1.03)</td>
<td></td>
</tr>
<tr>
<td>nursing home vs home age</td>
<td></td>
<td>1.03 (1.01–1.05)</td>
<td></td>
</tr>
<tr>
<td>nursing home vs death age</td>
<td></td>
<td>1.01 (1.00–1.03)</td>
<td></td>
</tr>
</tbody>
</table>

† Test for overall before/after differences showed a significant change in the odds of discharge dispositions (p = 0.0197). Odds ratios showed an increase in the odds of the first listed outcome in the after period. Before/after comparison of home or rehabilitation versus death dispositions was significant (p = 0.0063), showing a relative increase in the odds of a discharge to home or rehabilitation. The other two outcome comparisons (home or rehabilitation compared with skilled nursing facility, and skilled nursing facility compared with death) were not significant (p > 0.017).

‡ Test for overall effect of age was significant (p = 0.0006). Odds ratios indicated an increase in the odds of the first listed outcome per year of age. There was a significant increase in the relative odds of being discharged to a skilled nursing facility versus home or rehabilitation (p = 0.0002). No significant age effect after a Bonferroni correction was found in the other two comparisons of discharge outcomes: home or rehabilitation compared with death (p = 0.0319) and skilled nursing facility compared with death (p = 0.1286).

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Postinjury outcome measures, especially at time points beyond discharge from the hospital, were not available. Nonetheless, we believe that only a prospective study can be utilized to examine the potentially weak associations between any NICU interventions and outcomes, such as mortality rate or functional status, months or years later. Finally, there was no cost–benefit analysis, no patient and family satisfaction data, or quality of life assessment.

* This model was constructed using a nominal logistic regression analysis. Abbreviation: df = degrees of freedom.

‡ Test for overall effect of age was significant (p = 0.0006). Odds ratios indicated an increase in the odds of the first listed outcome per year of age. There was a significant increase in the relative odds of being discharged to a skilled nursing facility versus home or rehabilitation (p = 0.0002). No significant age effect after a Bonferroni correction was found in the other two comparisons of discharge outcomes: home or rehabilitation compared with death (p = 0.0319) and skilled nursing facility compared with death (p = 0.1286).

**Authors** used logistic regression to assess the independent effect of certain variables on recovery. We applied a more appropriate analytical method given the presence of censored observations.

Our study has certain limitations. It is a retrospective analysis using historical controls in a single university hospital. The NICU head trauma subpopulation showed some differences between the two periods studied. Although the demographics were quite comparable, fewer admissions were made through physician referrals and more through hospital transfer or the emergency department in the after period, reflecting a shift in the admission service patterns and bed allocation among the ICUs, also seen in the UHC-based expected outcomes (Table 1). Another potential limitation may lie in the use of UHC-based expected mortality rate and LOS, rather than other indices of severity, such as the Acute Physiology and Chronic Health Evaluation II, Physiologic Stability Index, Mortality Probability Model, which have been applied in numerous previous trials in critically ill adults and children. The UHC regression model, however, is currently being used at more than 100 university hospitals to adjust outcomes. Data are entered prospectively for each patient, constituting an advantage compared with the retrospective collection of data to calculate the other indices. The fact that an important prognostic variable, such as the GCS score, was documented in only 60 to 82% of the records is indicative of the difficulties encountered in a retrospective analysis. Furthermore, based on our study data we were unable to assess the relative impact of a more rigorous implementation of head trauma management protocols and the avoidance of secondary brain insults or medical complications based on the mere presence of the neurointensivist-led team in the NICU. Other postinjury outcome measures, especially at time points beyond discharge from the hospital, were not available. Nonetheless, we believe that only a prospective study can be utilized to examine the potentially weak associations between any NICU interventions and outcomes, such as mortality rate or functional status, months or years later. Finally, there was no cost–benefit analysis, no patient and family satisfaction data, or quality of life assessment.

Authors of several studies of nonneurological patients have compared the outcomes before and after the introduction of an intensivist as well as the transformation of the ICU from an open to a closed or semiclosed model. Data from these studies have shown improved outcomes with the new model. Regarding the neurological and neurosurgical ICU population, there are data suggesting better outcomes in the NICU as a whole, or in specific NICU diagnostic subpopulations, such as patients with ICH. To our knowledge, our study is the first in this country to be focused on the NICU head trauma subpopulation. Worldwide, there has been only one previous report from Sweden in which authors have reported favorable outcomes in patients with head trauma before and after the establishment of an NICU.

Outcomes in that series were significantly better in patients with GCS motor scores of 4 or greater on admission (good recoveries increased from 15 to 52%), indicating that secondary brain injuries were avoided in patients with milder primary injuries when they had been treated in an environment with better neurological surveillance and more aggressive treatment protocols. Note, however, that those factors may have been applied in numerous previous trials. In summary, the neurointensivist-led team approach and the transition from an open unit model to a semiclosed one were associated with improvements in several outcomes in patients with head trauma. Additional studies are warranted to determine the impact of this model of care at more than one institution, evaluate the specific contribution of healthcare personnel or specific treatment protocols, estimate NICU and hospital cost savings, and assess long-term outcomes.

Conclusions

In summary, the neurointensivist-led team approach and the transition from an open unit model to a semiclosed one were associated with improvements in several outcomes in patients with head trauma. Additional studies are warranted to determine the impact of this model of care at more than one institution, evaluate the specific contribution of healthcare personnel or specific treatment protocols, estimate NICU and hospital cost savings, and assess long-term outcomes.

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Address reprint requests to: Panayiotis N. Varelas, M.D., Ph.D., Departments of Neurology and Neurosurgery, Henry Ford Hospital, 2799 West Grand Boulevard, Detroit, Michigan 48202-2689. email: varelas@neuro.hfh.edu.