Routine preoperative blood testing in pediatric neurosurgery

Clinical article

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Object. The frequency with which routine preoperative blood test results predict perioperative or postoperative complications is insignificant. The unnecessary ordering of routine tests increases the financial costs and patients’ distress. The authors evaluated the effects of routine preoperative testing on patient management and the overall financial costs.

Methods. The authors retrospectively reviewed the medical records and laboratory data for 355 children admitted to the neurosurgical department for elective procedures over a 5-year period (January 2008–December 2012). They excluded all patients admitted for imaging or surgical procedures requiring local anesthesia, and they recorded the results of preoperative and previous (up to 6 months before surgery) blood tests and any abnormalities noted.

Results. As a result of the 3489 blood tests ordered preoperatively for 328 (94.6%) of the 355 patients, 29 abnormalities (9%) were detected. Most of these abnormal values were near the reference range, and none significantly affected the progression of scheduled procedures. For only 1 patient (0.28%) was the procedure cancelled because of an abnormality (preoperative partial thromboplastin time), which further testing showed to be a false-positive result. The cost of these tests over 5 years was 5205–10,410 euros ($6766–$13,533 US).

Conclusions. Preoperative tests should be selectively requested on the basis of clinical indication.

Keywords • routine blood testing • preoperative workup • routine coagulation screen • routine full blood count

The use of routine preoperative blood testing for adults has been thoroughly evaluated in the literature; most authors conclude that such tests, if ordered without a clinical indication, are expensive and not useful.3,5,7,18 Although it is known that the best approach for preoperative assessment of the patient is to take a full history and conduct a physical examination, routine screening tests are frequently ordered despite the limited insight they provide into the patients’ perioperative and postoperative course.13,22 The same preoperative protocol is applied to healthy children undergoing elective surgery, and its effectiveness has been the focus of many studies.6,10

Pediatric neurosurgical procedures are complex and require comprehensive preoperative evaluation for determining the fitness of a child for anesthesia and surgery.20 There is no published evidence regarding the usefulness of preoperative blood testing before pediatric neurosurgery and whether the series of screening tests does in fact affect the management plan and outcome of elective surgery.

We hypothesized that most preoperative blood testing conducted before elective pediatric neurosurgery procedures is unnecessary, expensive, and, even if results are abnormal, does not always alter the management plan.

Methods

We conducted a retrospective review of the medical charts and laboratory results of children consecutively admitted for elective neurosurgical procedures from January 2008 through December 2012. We included only those patients admitted for neurosurgical procedures re-
requiring general anesthesia. Exclusion criteria were patients admitted for elective imaging requiring general anesthesia (that is, MRI), observation, and surgical procedures requiring local anesthesia.

The data gathered included the patient’s age, sex, date of admission, date of procedure, type of procedure, results of preoperative and previous (up to 6 months before surgery) blood tests. We also noted the effect of abnormal results on the progression of a scheduled procedure and on perioperative or postoperative complications.

We accessed the laboratory data through a computer system that documented the results of all blood tests ordered in the hospital. The results of the following preoperative blood tests were analyzed: complete blood count, urea and electrolytes, and coagulation screening.

As common practice at the Children’s University Hospital in Dublin, Ireland, these blood tests are routinely requested before all elective surgeries. We recorded the results of white cell counts; platelet counts; hemoglobin, urea, creatinine, potassium, sodium, and fibrinogen levels; prothrombin times (PTTs); and activated partial thromboplastin times (APTTs). An abnormal result was defined as a value that did not fall within the standard reference range provided by the hospital laboratory. These reference ranges are based on a 95% confidence interval. 

An estimate of the costs of each blood test was obtained from the hospital’s laboratory manager. Costs were 5–10 euros ($6.50–$13.00 US) per test. Because this was a retrospective study and because cost depends on the volume of blood collected for each sample, we were not able to verify the exact cost of each individual blood test for the patients in our cohort.

This study was initially undertaken as part of a departmental audit, which does not require prior ethics and research board approval. However, we strictly maintained patient confidentiality and stored our database on approved encrypted institutional computers.

### Results

During the study period, 515 patients were admitted to the neurosurgical department for elective procedures. We excluded 160 patients who were admitted for scanning, surgical procedures requiring local anesthesia, and other minor procedures not requiring sedation. The remaining 355 patients met our inclusion criteria and consequently formed our study cohort.

Among these 355 patients, 202 were male, mean age was 2 years and 5 months (range 17 days to 13 years), and 417 procedures were performed (Table 1). Only 1 scheduled procedure (0.28%) was cancelled because of an abnormal preoperative blood test value.

A total of 3489 preoperative blood tests were ordered (Table 2) for 328 patients. Of these patients, 399 complete blood count tests were ordered for 326 patients (91.8%), 366 urea and electrolyte tests were ordered for 311 patients (87.6%), and 276 coagulation screen tests were ordered for 239 patients (67.3%). For 27 patients (7.6%), no preoperative blood tests were ordered (Fig. 1).

### Complete Blood Count

Among the 399 samples submitted for complete blood count, 14 (4%) were not analyzed because the sample was not sufficient or had clotted.

**Hemoglobin.** Of the 399 complete blood count tests performed, 15 abnormal hemoglobin results (4%) were noted for 14 patients. The mean (± SD) hemoglobin level was 10.2 ± 3.78 g/dl. The lowest value (2.9 g/dl) was reported for a 1-year-old girl who underwent an uneventful encephalocele repair. This patient received a blood transfusion intraoperatively, and no cause was found for the anemia. The highest value (15.4 g/dl) was reported for a 6-month-old boy who underwent an uneventful extended strip craniotomy for sagittal synostosis.

**Platelet Count.** Of the 399 platelet counts performed, 116 (29%) were abnormal. The mean (± SD) platelet count was 526.4 ± 199.9 × 10^9/L. The highest platelet count recorded was 886 × 10^9/L, and the lowest was 19 × 10^9/L. The highest count was recorded for a 24-day-old girl in whom a ventriculoperitoneal shunt was inserted for congenital hydrocephalus. The lowest count was recorded for the 1-year-old girl mentioned earlier who had a low hemoglobin level of 2.9 g/dl and underwent encephalocele repair. The platelet count for this 1-year-old patient was 119 × 10^9/L (reference range 150–450 × 10^9/L), and she did not receive a perioperative platelet transfusion nor did she experience postoperative hemorrhage.

**White Cell Count.** Of the 399 white cell counts performed, 30 (8%) were abnormal. The highest white cell count was 21.2 × 10^9/L, and the lowest was 2.2 × 10^9/L. The lowest count was recorded for a 7-year-old girl with a cerebellar lesion, which was removed a day after the blood testing. The highest count was recorded for a 1-month-old girl who underwent insertion of a ventriculoperitoneal shunt. The mean (± SD) white cell count was 11.05 ± 7.15 × 10^9/L. Neither of the 2 patients just mentioned underwent repeat blood testing, and the course of each procedure was not altered.

### Table 1: Procedures performed*

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>repair of encephalocele/myelomeningocele</td>
<td>117</td>
</tr>
<tr>
<td>VP shunt procedure (insertion/revision)</td>
<td>90</td>
</tr>
<tr>
<td>cranial vault remodeling (for craniosynostosis)</td>
<td>89</td>
</tr>
<tr>
<td>craniotomy for intracranial lesion</td>
<td>48</td>
</tr>
<tr>
<td>insertion of ICP monitor</td>
<td>20</td>
</tr>
<tr>
<td>endoscopic 3rd ventriculostomy</td>
<td>14</td>
</tr>
<tr>
<td>excision of epidermoid/dermoid cyst (skull)</td>
<td>10</td>
</tr>
<tr>
<td>biopsy of intracranial lesion (open/stealth guided)</td>
<td>10</td>
</tr>
<tr>
<td>cranioplasty</td>
<td>8</td>
</tr>
<tr>
<td>endoscopic fenestration of arachnoid cyst</td>
<td>7</td>
</tr>
<tr>
<td>release of congenital tethered cord</td>
<td>3</td>
</tr>
<tr>
<td>evacuation of cephalohematoma</td>
<td>1</td>
</tr>
<tr>
<td>total</td>
<td>417</td>
</tr>
</tbody>
</table>

* ICP = intracranial pressure; VP = ventriculoperitoneal.
Routine preoperative blood testing

Urea and Electrolytes

Among the urea and electrolytes samples, 4 (1%) of 366 samples were not analyzed because of sample contamination.

**Potassium.** Among the 366 samples submitted for potassium analysis, 5 were hemolyzed and thus not suitable for analysis. Potassium levels were abnormal for 16 (4%) of the 366 tests performed. The lowest potassium level (2.8 mmol/L; reference range 3.5–5 mmol/L) was reported for an 18-month-old boy with subdural nontraumatic hemorrhage. Blood was collected on the same day the drainage procedure was performed, and the case management was not altered. After the procedure, the patient received potassium supplementation. Blood was collected on the same day the drainage procedure was performed, and the case management was not altered. After the procedure, the patient received potassium supplementation. The highest potassium level (6.5 mmol/L; reference range 3.5–5.5 mmol/L) was reported for a 7-month-old boy with sagittal synostosis, who was scheduled to undergo total vault remodeling. Preoperatively, 2 potassium tests had been requested, and results for each indicated elevated potassium (second result 5.7 mmol/L). These results did not alter case management or result in any complications.

**Sodium.** Sodium levels were abnormal in 2 patients for 3 (1%) of the 366 tests performed. The values were 153 mmol/L and 145 mmol/L (reference range 133–144 mmol/L). The patient with 153 mmol/L sodium was given intravenous hydration before surgery. The procedure was not delayed or rescheduled. The sodium level in a repeat sample, collected postoperatively, was within reference range.

**Urea.** Urea levels were abnormal for 34 (9%) of 366 samples. The mean (± SD) urea level was 6.74 ± 1.23 mmol/L. The highest value (8.7 mmol/L; reference range 2–6 mmol/L) was reported for a 1-year-old girl scheduled to undergo an endoscopic third ventriculostomy. The lowest value (1.8 mmol/L; reference range for patients <1 year of age 1–6 mmol/L) was reported for a 4-month-old girl with sagittal synostosis, who was scheduled to undergo extended strip craniotomy. Both procedures were performed despite these abnormal results.

**Creatinine.** Creatinine levels were abnormal for 7 (2%) of 366 samples. Each of these 7 patients was younger than 4 years, and their results were interpreted according to an age-adjusted reference range (<4 years 15–40 μmol/L). The mean (± SD) creatinine level was 24 ± 19 μmol/L. The highest value (67 μmol/L) was reported for a 9-month-old boy with craniosynostosis who underwent frontoorbital advanced remodeling for metopic synostosis. Because urea, sodium, and potassium levels were within the reference range, he did not require treatment for the increased creatinine level before surgery. A repeat sample collected 3 days postoperatively indicated a creatinine level of <27 μmol/L. The lowest creatinine level (12 μmol/L) was reported for a 15-month-old girl who underwent ventriculoperitoneal shunt insertion. Neither procedure was affected by these abnormal creatinine levels.

Coagulation Screen

Among samples collected for coagulation screening, 28 (10.1%) were not suitable for analysis because they were either inadequate (underfilled) or clotted.

**Prothrombin Time.** Prothrombin time results were divided according to patient age because reference ranges vary by age group (Table 3). Overall, PT was abnormal for 15 (5%) of 276 samples. The longest PT (17.4 seconds) was reported for a 22-month-old boy who underwent frontoorbital advancement remodeling for metopic synostosis. The shortest PT (10 seconds) was reported for a 47-month-old girl who underwent biopsy of the pineal gland. No repeat tests were ordered for any patients, and all procedures were performed as scheduled without postoperative complications.

**Partial Thromboplastin Time.** Partial thromboplastin time results were abnormal for 68 (25%) of 276 sam-

![Fig. 1. Distribution of blood tests ordered for patients. “No bloods” means that no blood tests were ordered.](image-url)
Another finding was the high number of previous blood tests that had been ordered before hospital admission for the elective procedure or up to 6 months earlier were considered to be relevant to this study. Of the 328 patients for whom routine preoperative blood tests were ordered, 98 had been tested either during the same month of the procedure or up to 6 months earlier. Most (58/98) results from previous blood tests were within reference range, and those that were abnormal (40/98) were close to the reference range (Fig. 2).

**Costs**

Given the variable volume of individual samples, it is difficult to ascertain the exact cost of each test in our study. The volume of a sample influences the amount of reagents required and, ultimately, the cost of running the test. The estimated cost per test was 5–10 euros ($6.50–$13.00 US). On the basis of these estimates for individual tests, we calculated the overall cost for all preoperative blood testing conducted during the 5-year period to be 5205–10,410 euros ($6766–$13,533 US). Also during the 5-year period, the estimated cost of the blood testing with results within the reference range was 3475–6950 euros ($4518–$9035 US). Thus, blood testing for which results were within reference range accounted for 61% of the total cost of preoperative blood testing.

**Discussion**

Our study revealed that, overall, preoperative blood testing does not contribute to the ultimate outcome of a procedure. Only one planned procedure was cancelled because of an apparent hematologic abnormality detected by testing; the abnormality turned out to be insignificant. It is not fully known why physicians routinely request preoperative tests.17

The American Society of Anesthesiologists published an updated Practice Advisory for Preanesthesia Evaluation, which states that preoperative tests should not be ordered routinely and that they should be ordered only on a selective basis to improve perioperative patient management.1 On the other hand, the National Institutes of Health and Clinical Excellence, United Kingdom, has also published guidelines on preoperative testing and recommends that all children older than 16 years who are scheduled for neurosurgical procedures should undergo preoperative testing (renal profiles, complete blood count, coagulation profile, and urine analysis) only when indicated.15

Our hospital guidelines state that all patients scheduled for minor procedures should not undergo preoperative blood testing and that only those scheduled for major procedures should undergo complete blood count testing, urea and electrolyte testing, and coagulation screening. Our study revealed that our current practice does not conform to the established guidelines as 82 patients (67.8%) scheduled for procedures underwent preoperative testing.

Neither patients nor surgeons benefited from clinically irrelevant blood testing, and the abnormalities found were not taken into consideration for most cases. We also found that most of the abnormalities were insignificant and that the abnormal laboratory values did not deviate significantly from the reference ranges.

Another finding was the high number of previous

<table>
<thead>
<tr>
<th>Group</th>
<th>Reference Range (sec)</th>
<th>Above Reference Range (%)</th>
<th>Below Reference Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (1–12 mos)</td>
<td>11.5–25.3</td>
<td>1 (0.36)</td>
<td>1 (0.36)</td>
</tr>
<tr>
<td>2 (1–5 yrs)</td>
<td>12.1–14.5</td>
<td>4 (1.4)</td>
<td>7 (2.5)</td>
</tr>
<tr>
<td>3 (&gt;5 yrs)</td>
<td>11.7–16.1</td>
<td>2 (0.72)</td>
<td>0</td>
</tr>
</tbody>
</table>

* Based on laboratory reference ranges for age groups established by the Children’s University Hospital, Dublin, Ireland.

**Fibrinogen.** Fibrinogen levels were abnormal for 16 (6%) of 276 samples. Results were interpreted according to age group reference ranges. Fibrinogen levels were highest (4.66 g/L) and lowest (0.93 g/L) for patients in Group 2 (1–5 years of age; reference range 1.6–4.01 g/L). Fibrinogen levels for patients in the other 2 groups were either slightly above or below the range. The mean (± SD) value for all results was 3.5 ± 1.31 g/L. The lowest value was reported for a 2-year-old boy; among 3 repeat tests, 2 had abnormal results (1.24 g/L and 1.21 g/L). The highest value was reported for a 6-year-old girl with unicoronal synostosis, who was scheduled for frontoorbital advancement remodeling. No other blood testing was performed before or after her procedure, and no complications were noted.

**Previous Blood Testing**

Any blood tests that had been ordered before hospital admission...
Routine preoperative blood testing

blood test results that were available; these results could have been substituted for the unnecessary preoperative tests. Macpherson et al. suggested that previous blood test results from up to 1 year before surgery could be used as substitute preoperative test results if they are within normal limits and no clinical indication exists for repeating them. Narr et al. concluded that patients who have been preoperatively assessed by history and physical examination and determined to have no indication for laboratory testing can safely undergo anesthesia and surgery without any complications. Ansermino et al. established that most routine preoperative blood abnormalities in children are clinically irrelevant to scheduled surgery. Similarly, Meneghini et al. studied 2 groups of pediatric patients scheduled for minor elective surgery; one group underwent routine preoperative testing and the other underwent selective blood testing. These authors concluded that preoperative blood tests should be selectively requested. By eliminating all unnecessary preoperative blood testing, the neurosurgical department in our hospital could save up to 1041–2082 euros per year.

In the field of neurosurgery, few studies have assessed the effects, if any, that the results of this routine testing may have. One study of adult neurosurgical patients evaluated use of a screening questionnaire intended to standardize history taking and containing built-in algorithms advising when routine blood testing should be performed. The authors found that this questionnaire was accurate for identifying those patients for whom preoperative blood tests were indicated. When they compared the test results of indicated tests and nonindicated tests, they noted fewer abnormal results for the nonindicated than for the indicated test groups. In the adult population, preoperative routine blood testing may provide an opportunity to screen for conditions such as diabetes mellitus, thereby resulting in early implementation of treatment. However, the same cannot be said for the pediatric setting.

Routine coagulation testing in particular has been found to have very low yield. This finding also applies to neurosurgical patients scheduled for elective procedures; only 7% of these test results have been found to be abnormal and to indicate increased bleeding potential. For most patients, the potential for prolonged bleeding can be predicted on the basis of clinical history. Prothrombin time is an unreliable predictor for hemorrhagic complications. Among neurosurgical patients, it has been found that among those undergoing elective procedures, only a very small percentage (< 1%) had hemorrhagic complications; and among these, preoperative PT was within reference range for over 94%. For most patients, elevated PT does not translate to hemorrhagic complications; as seen with our cohort, most patients with elevated PT go on to have uncomplicated procedures. Hemophilia B prevalence is highest in Ireland (8.07/100,000 male patients); patients with Von Willebrand disease are registered in the national registry. Given these numbers, blanket routine coagulation tests are of little value. A focused history, concentrating on family history of coagulopathy and symptoms or signs of coagulopathy, would be more beneficial. We propose an algorithm for selecting which patients require preoperative blood testing (Fig. 3).

Conclusions

Compared with other surgical procedures, most pediatric neurosurgical procedures can be considered highly invasive. However, neurosurgeons are able to determine which of their procedures they deem to pose less risk, and it is for these procedures that routine preoperative blood
testing protocols could be reassessed to mitigate unnecessary child distress. Previous blood test results should be taken into account before requesting more tests, especially if results were within reference ranges and if the child’s clinical condition is unchanged. A blanket approach to routine preoperative testing of patients in the absence of clear indication may lead to unnecessary surgical delays and patient discomfort. Ultimately, we hope that our findings highlight the topic, create awareness, and stimulate debate.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Mandiwanza, Kaliaperumal, Crimmins. Acquisition of data: Almesbah. Analysis and interpretation of data: Mandiwanza, Almesbah. Drafting the article: Almesbah. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Mandiwanza. Study supervision: Kaliaperumal, Caird, Crimmins.

References

Routine preoperative blood testing


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