

Predicting the Need for Topical Anesthetic in the Pediatric Emergency Department

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ABSTRACT. *Objective.* To investigate the potential for pediatric emergency department (ED) triage nurses to apply a topical anesthetic (ie, eutectic mixture of local anesthetic) for intravenous catheter (IV) insertion.

Methods. Prospective cross-sectional survey over a 2-month period, with post hoc application of internally developed prediction rules. Eligible patients were children presenting to the ED triage area of an urban children's hospital.

Results. A total of 2596 (86.7% of eligible children) had a triage nursing prediction performed. Nurse prediction of IV insertion had a sensitivity of 72% (95% CI: 66,78), a specificity of 90% (88,91), and a positive predictive value (PPV) of 49% (44,54). Objective factors such as high-risk medical history (chronic neurologic, hematologic, cardiac, endocrine, or gastrointestinal illness) and high-risk chief complaint (gastrointestinal illness, skin infection, and previous seizure) were incorporated into a predictive score used to predict IV insertion independently with a sensitivity of 33% (27,39) and a PPV of 43% (44,54). Addition of the objective predictors to nursing prediction increased the sensitivity to 76% (70,81) with a PPV of 43% (38,47). Of the patients, 95% received an IV insertion \leq 45 minutes after triage, 89% \leq 60 minutes after triage. Of the IV insertions, 68% were placed in the dorsum of the hand.

Conclusions. The prediction of an experienced triage nurse can identify most patients requiring an IV in a pediatric ED. Incorporation of objective criteria other than nursing prediction into this decision process can decrease the amount of wasted product at the expense of less sensitive identification. The timing of IV insertion in our ED would allow for full medication effect of the currently marketed topical anesthetics in the majority of ED patients. *Pediatrics* 1999;104(2). URL: <http://www.pediatrics.org/cgi/content/full/104/2/e19>; *topical anesthetic, intravenous cannulation, children, eutectic mixture of local anesthetic.*

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ABBREVIATIONS. IV, intravenous catheter; ED, emergency department; RVC, reason for visit classification; PPV, positive predictive value; EMLA, eutectic mixture of local anesthetic.

Topically applied local anesthetics have been shown to reduce the pain associated with intravenous catheter (IV) insertion significantly.¹⁻⁴ However, it has not been common practice to use these medications in the emergency department (ED). The requirements for successful and efficient application of topical anesthetic in the ED are 1) prospective identification of patients receiving IV insertions and 2) sufficient time between triage and IV insertion for the medication to take effect. A previous study demonstrated that most IV insertions in the pediatric ED are placed \geq 1 hour after initial patient triage.⁵ The objective of this study is to assess the ability of triage nurses to predict a patient's need for IV insertion and to delineate patient characteristics that may predict IV insertion in the ED.

METHODS

Patients seen in the ED of an urban children's hospital over a 2-month period were evaluated by the triage nurse for the potential of receiving an IV. Patients were excluded if they had existing IV access (either from a central line catheter or prehospital IV insertion), or if the patient was placed in an ED room without being seen in triage. A hidden area of the triage sheet was pre-stamped with a yes or no selection. The nurses were instructed to circle yes if they thought that the patient had a \geq 50% chance of requiring an IV catheter during the ED visit and to circle no for all other patients. The triage nurse's prediction was not visible to the physicians and nurses caring for the patient and making decisions regarding IV insertion, and the treating physicians were not aware that this study was being conducted. To avoid selection bias, patients were used in the analysis if the nurse performed predictions on \geq 80% of the total number of patients she triaged. The study was approved by the hospital's Committee for the Protection of Human Subjects (institutional review board) with no requirement for written consent.

ED records were abstracted subsequently by 1 of 3 trained research assistants using a standardized form. The outcome of interest was an attempt at IV insertion \geq 60 minutes after triage. Success of the attempt and IV location were noted for those patients who underwent IV insertion. Data were abstracted on the following potential predictors of IV insertion: the triage nurse's prediction, demographic information, chief complaint, and medical history. Chief complaints were categorized using the reason for visit classification (RVC) coding system.⁶ For medical history categorization, 2 of the investigators reviewed each patient's triage record and independently assigned the record to 1 of 14 categories. These categories were created by 1 of the investigators, who was blinded to the IV insertion status of the patients. Interrater agreement of history categorization was evaluated using the κ statistic.

The goals of the analysis were to identify those factors known at the time of triage that are predictive of IV insertion and to use those factors in a prediction score. The original sample was split

randomly into a development set (80% of observations) and a validation set. First, using the development set, the association between individual categorical predictors and IV insertion was measured by the relative risk with 95% CIs. For age, the Mann-Whitney *U* test was used to compare the median values between those with and those without the outcome. Next, multivariable models to predict IV insertion were developed using a backward elimination stepwise logistic regression with a significance level to remove variables of $P > .15$. Those variables found to be independently predictive of IV insertion were included in a simple additive linear score. Then, the sensitivity, specificity, and positive predictive value (PPV) of the score were determined at each possible cutoff value. Test characteristics then were evaluated for the predictive scores applied to the validation set. Statistical analyses were performed using Stata Version 5.0 (Stata Corp, College Park, TX).

The sample size needed for the study was based on the desire to estimate the sensitivity of nursing prediction with a given degree of precision. Assuming an overall IV placement rate of 12% (based on previous work in the study setting) and a sensitivity of nursing prediction of 75%, a sample size of 2500 children (300 IV insertions placed) was calculated to allow estimation of sensitivity with a 95% CI width of 5%. The resulting sample size with 80% of subjects used for development of a prediction model would permit the evaluation of up to 24 predictor variables in a multivariate logistic regression model (10 outcomes per independent variable).

RESULTS

A total of 4926 patient records were abstracted during the study period. Of the nurses, 50% (23/46) performed predictions on $\geq 80\%$ of their patients. Of these 2994 patient records, 2596 (86.7%) listed a nursing prediction and were included in the analysis. This sample was split into a development set ($n = 2052$) and a validation set ($n = 544$).

Overall, 12.1% of patients ($n = 314$) underwent IV insertions in the ED. Of the patients who received an IV insertion, 92% had time and IV location data recorded on the medical record. Time from initial triage to IV insertion was >60 minutes in 88% (95% CI: 84,92) of patients and was >45 minutes in 95% (91,98) of patients. The IV was placed in the dorsum of the hand in 68% (62,75) of patients.

In the development set (with an IV insertion prevalence of 12.3%), nurses predicted IV insertion with a sensitivity of 72% (66,78), a specificity of 90% (88,91), a PPV of 49% (44,54), and a negative predictive value of 96% (95,97). (Table 1). Patients predicted to need an IV were 11.8 (9.2,15.2) times more likely to receive an IV than were patients who were not predicted to need an IV. The sensitivity and PPV of a positive nursing prediction in the validation set (overall IV prevalence 11.4%) were 71% (58,82) and 42% (32,52), respectively. The sensitivity and PPV of the set of

patients excluded because of inconsistent nurse participation (overall IV prevalence 12.3%) were 74% (64,83) and 54% (45,63), respectively.

When considered as a continuous variable, age was not associated significantly with having an IV inserted. The median age of patients who received an IV was 4.4 years versus 4.5 years for patients who did not receive an IV ($P = .49$). We also tested an a priori hypothesis that patients <1 year of age would be at an increased risk of having an IV placed. The relative risk for patients <1 year was 1.4 (95% CI: 1.1,1.8). There was no difference between boys and girls in rates of IV insertion.

In the development set, 26.5% of children were considered to have a possibly important medical history as reported to the triage nurse. The agreement between the 2 investigators on history assignment was excellent ($\kappa = 0.87$). The risk of getting an IV was 9.7% for children with no significant medical history. IV risk was determined for each category of history, and those categories with a risk of $\geq 30\%$ were considered high risk (Table 2).

There were 249 different chief complaint codes represented. Several steps were taken to reduce the number of variables for consideration. First, several groups of similar chief complaints were created. For example, all RVC codes beginning with J2 (lacerations and cuts) were combined into the chief complaint of laceration. Similarly, RVC codes S525.0 (nausea), S530.0 (vomiting), S540.0 (gastrointestinal infection), S550 (abdominal pain), and S590.0 (diarrhea) were combined into the chief complaint of gastrointestinal illness. Next, we excluded any chief complaint that did not account for $\geq 3\%$ of all visits (ie, $n = 78$) or $\geq 2\%$ of visits resulting in an IV (ie, $n = 6$). This left 13 chief complaints, accounting for 66% of all visits, eligible for additional consideration.

Backward elimination stepwise logistic regression was performed with IV insertion as the outcome variable and age <1 year, high risk history, and the 13 chief complaints selected as described above were included as potential predictors. Eight variables were retained in the model using a conservative criterion of $P > .15$ for variable removal. These eight variables then were used to generate an additive prediction score. (Table 3) Two variables (<1 year of age and chief complaint of fever) with an OR < 2 were dropped. Of the remaining variables, those with ORs between 2 and 5 were assigned a value of 1 point, those with ORs > 5 were valued at 2 points, and those with ORs < 0.5 were assigned a value of -1 point. Prediction score A, consisting of six objective predictors only, has a range of possible values from -1 to 4. Prediction score B was created combining the six objective predictors plus the nursing prediction in triage with a positive nursing prediction given a value of 2 points. The sensitivity, specificity, and PPV of nursing prediction alone, and of each score at various cutoff scores are shown in Table 4. The PPV ranged from 0.43 to 0.57, and the sensitivity ranged from 0.33 to 0.76. The scores all performed slightly less well in terms of sensitivity and PPV in the validation set. Figure 1 demonstrates the sensitivity of each level of prediction score with and

TABLE 1. Triage Nurse Prediction of IV Insertion

	IV Placed	IV Not Placed	Total
Development set			
Predicted IV	182	188	370
Predicted IV	70	1612	1682
Total	252	1800	2052
Validation set			
Predicted IV	44	60	104
Predicted IV	18	422	440
Total	62	482	544
Nurses excluded from the analysis			
Predicted IV	66	57	123
Predicted IV	23	580	603
Total	89	637	726

TABLE 2. Medical History Categories

Description	N	Percent Having IV Placed
Asthma	364	8.0
None	1744	9.7
Other respiratory (eg, cystic fibrosis, tracheostomy, or bronchopulmonary dysplasia)	9	11.1
Seizures	28	14.3
Renal (eg, renal failure or renal transplant)	15	13.3
Cardiac (eg, congenital heart disease other than isolated atrial or ventricular septal defect or mitral valve prolapse; dysrhythmia; prolonged QT; or presence of pacemaker)	16	*31.3
Oncologic	22	*31.8
HIV infection	6	*33.0
Endocrine/Metabolic (eg, diabetes mellitus, congenital adrenal hyperplasia, or inborn errors of metabolism)	20	*35.0
Other	28	*35.7
Other neurologic (eg, ventriculoperitoneal shunt, muscular dystrophy, or myopathies, hemiplegias)	52	*36.5
Gastrointestinal (eg, liver transplant, inflammatory bowel disease, cyclic vomiting; not to include constipation, chronic abdominal pain, or gastroesophageal reflux)	22	*54.5
Hematologic (eg, sickle cell disease, hemophilia, or any cytopenia)	45	*55.6
Recent tonsillectomy	4	*75.0

* Considered as high-risk medical history.

TABLE 3. Adjusted ORs of Variables Remaining After Stepwise Logistic Regression (Development Set, $n = 2052$)

Predictor Variable Included*	Adjusted OR	95% CI	Points Assigned in Prediction Score
Age <1 y	1.6	1.1, 2.3	0
High-risk medical history	8.4	5.8, 11.9	+2
Chief complaint			
Upper respiratory infection/cough	0.4	0.2, 1.2	-1
Fever	1.5	1.1, 2.0	0
Seizure	2.8	0.9, 9.1	+1
Gastrointestinal (includes nausea/vomiting, diarrhea, abdominal pain, and gastrointestinal infection)	3.7	2.7, 5.1	+1
Cellulitis or abscess	10.6	3.0, 36.9	+2
Referred by doctort	7.8	1.4, 43.6	+2

* The following chief complaints were not significantly associated with IV insertion at $P > .15$ and dropped from the model: respiratory (including wheeze, asthma, and shortness of breath); accident, unspecified (RVC code J810.0); laceration; fussy infant (S080.1); extremity injury other than fracture; head trauma; and rash.

† Does not include all children referred by physician, only those in which referral was stated independently by the patient or parent at the time of triage.

TABLE 4. Test Characteristics of Prediction Scores

Criterion for Positive Score	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)
Development set			
Nurse prediction only	72% (66,78)	90% (88,91)	49% (44,54)
Prediction score A (objective predictors only), score ≥ 2	33% (27,39)	94% (93,95)	43% (36,51)
Prediction score B (objective predictors plus nurse prediction), score ≥ 2	76% (70,81)	86% (84,87)	43% (38,47)
Prediction score B (objective predictors) plus nurse prediction, score ≥ 3	49% (43,55)	95% (94,96)	57% (50,64)
Validation set			
Nurse prediction only	71% (58,82)	88% (84,91)	42% (33,52)
Prediction score A (objective predictors only), score ≥ 2	31% (20,44)	94% (91,96)	40% (26,55)
Prediction score B (objective predictors plus nurse prediction), score ≥ 2	74% (61,84)	84% (81,87)	37% (29,46)
Prediction score B (objective predictors) plus nurse prediction, score ≥ 3	46% (33,59)	94% (91,96)	49% (36,63)

without nursing prediction. This sensitivity is related to the number of patients who would need to receive topical anesthetic in triage to achieve one successful anesthetic-IV event.

DISCUSSION

IV insertion and venipuncture are the common painful procedures performed on children in the ED. Intradermal injection and iontophoresis have been used to alleviate the pain associated with these procedures.^{7,8} However, these methods may be either painful or cumbersome to administer in a busy ED.

Young et al⁹ describe the successful use of eutectic mixture of local anesthetic (EMLA) for phlebotomy in pediatric practice. A disadvantage of using EMLA in the ED is the long application time required for effective anesthesia, necessitating early prediction of IV candidates. A previous retrospective study has demonstrated that >80% of children in our ED wait >60 minutes after initial triage to receive an IV.⁵ Nevertheless, patients must be identified prospectively in triage for this strategy to be effective.

The results of this study suggest that it is possible to predict with some accuracy who will benefit from

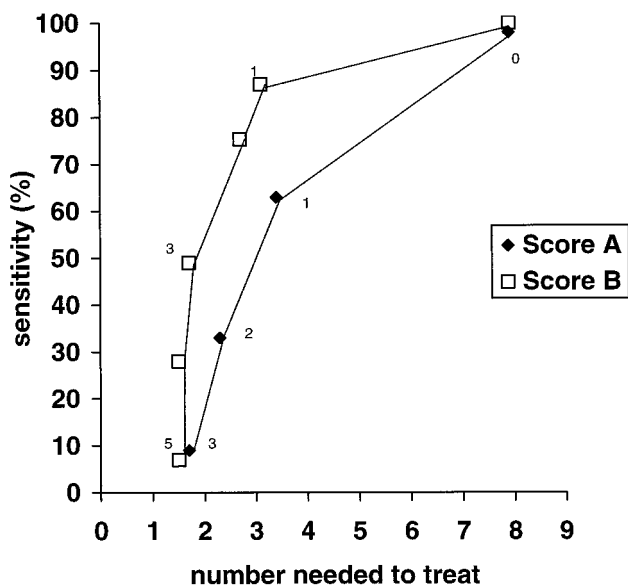


Fig 1. Predicting topical anesthetic in the ED. The sensitivity (%) of the various prediction scores versus the number of patients needed to treat for each successful anesthetic IV event. Score A represents objective predictors only. Score B represents objective predictors plus nursing prediction.

the application of a topical anesthetic before IV insertion in the ED. With nursing prediction alone, ~70% of the patients receiving an IV in our ED would have received a topical anesthetic in triage. However, twice as many patients than needed would have received anesthetic.

Objective measurements can predict with slightly less certainty which children will receive an IV. Patients with a medical history of recent tonsillectomy, cardiac, gastrointestinal, endocrine, neurologic, or oncologic disease were at high risk of receiving an IV. Patients with chief complaints relating to the gastrointestinal system, cellulitis or abscess, and seizures also were more likely to receive an IV. Patients who stated that they were referred to the ED by another physician were at higher risk, whereas a chief complaint of upper respiratory infection was protective of IV insertion.

We developed the prediction score to incorporate the objective measures that were associated most commonly with IV insertion. Although the prediction score using objective measures alone was less accurate than was nursing prediction alone, the addition of the objective measures to an initial nursing prediction would result in a higher PPV and thereby would decrease product wastage. Because each ED may have a unique level of cost risk that the administration is willing to endure, one could use a higher prediction score to lower the number of children who receive anesthetic unnecessarily. For example, in our ED using nursing prediction alone (PPV = 0.49), 2 patients would have to receive EMLA for every successful application at a cost of \$10.00 per application. If nursing prediction is used in conjunction with objective measures, indicated by a prediction score B of ≤ 3 (number needed to treat ≤ 1.75), this cost is reduced to $< \$8.77$ per successful application. The disadvantage is that, given the sensitivity of

the latter strategy, only 49% rather than 72% of potential applications would be identified in triage. This cost would increase if there is not sufficient time to allow peak anesthetic effect.

This study also confirms that the vast majority (88%) of the IV insertions in our ED were performed ≥ 1 hour from triage. Reinhardt and colleagues¹⁰ measured the waiting time until IV insertion in patients who received EMLA in the triage area of a pediatric ED and found that no additional waiting time occurred in patients receiving EMLA. Clearly, waiting times will depend on the ED location and type, time of day, and season. In settings with shorter waiting times, the health care providers, patients, and parents can decide whether it is important enough to wait the extra minutes for peak drug effect. Topical anesthetics other than EMLA may be useful in this context. In European studies¹¹⁻¹⁴, the topical application of amethocaine gel has demonstrated excellent efficacy for both adult and pediatric IV line insertion. This product has an onset time of ≤ 45 minutes. In our ED, this time period would have captured 95% of the IV insertions.

There are several limitations to the present study. We chose to include only the patients triaged by nurses who consistently recorded their predictions and excluded those patients whose nurses did not perform predictions at least 80% of the time. This strategy was chosen to minimize selection bias in which a nurse could choose to perform predictions on the so-called easy to decide patients. However, the strategy also could have excluded the predictions of less experienced nurses in whom the prediction decision is less apparent. Overall, the predictive ability of these nurses was similar to that of the included nurses. However, because we decided a priori to exclude nurses with poor participation, these patients were not included in the analysis.

The generalizability of the results of this study to other EDs, especially those with lower patient volume or in community settings, is not clear. The level of experience or training of the nursing staff and patient characteristics may differ enough to warrant additional study in these settings. The prediction score validated well in an independent sample of patients derived from the same population. Therefore, it is unlikely that the predictive ability of the scores are a result of overfitting the data. Although the prediction score may not be applicable in all emergency settings, the process by which we generated the score is sound and would lead to accurate and reliable prediction when used in this manner. Nevertheless, our data are most applicable to a high volume pediatric ED with a substantial proportion of chronically ill patients.

A final limitation is that the actual product was not used in the study. The logistics of anesthetic application and the inherent problems that accompany that procedure were not tested formally. Multiple studies suggest that EMLA is efficacious in providing analgesia for pediatric IV insertion^{2,4} and that its failure is related to the anxiety levels of the child and the duration of drug application.¹⁵ Furthermore, some investigators claim that the vasoconstrictive qualities of EMLA cream impedes successful IV insertion.¹⁶ No

prospective evaluation has been done to investigate this specific issue. Amethocaine gel is considered, albeit anecdotally, to cause less vasoconstriction than does EMLA cream. However, there are no current efforts to market this compound in the United States. Additional study should be directed toward prospective validation of these results in other clinical settings, as well as toward clinical trials that include formal economic analysis and comparison of various anesthetic agents.

CONCLUSIONS

A large number of patients could benefit from the application of a topical anesthetic in the triage area of a pediatric ED. The prediction of an experienced ED triage nurse can identify >70% of these patients. It also is possible to use objective criteria alone to identify these patients prospectively in triage. Moreover, incorporation of objective criteria other than nursing prediction into this decision process can decrease the amount of wasted product at the expense of less sensitive identification. This study also confirms that the timing of IV insertion in our ED would allow for full medication effect of the currently available topical anesthetics in the majority of ED patients.

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