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King Devick Test as a Monitor of Anesthetic Recovery. A validation study

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Keypoints

When compared to the Trieger Dot Test, the King Devick Test is a valid assessment tool in evaluating cognitive recovery of pediatric patients who receive sedation. In addition, our findings show that it may be more sensitive to cognitive impairment than the Trieger Dot Test.

Abstract

Introduction

It is recommended that pediatric patients be released from the post-anesthesia recovery area once they are no longer at risk for cardiorespiratory depression. However, these guidelines do not specify how a provider is to monitor recovery of neurocognitive status.

Previous studies have evaluated the utility of psychomotor tests to measure anesthetic recovery; however, most of these tests are time consuming and are rarely used in the post-anesthesia recovery area. The Trieger Dot Test (TDT) is one of these tests and is a well validated measure of anesthetic recovery. The King Devick Test (KDT) has emerged as a scientifically valid test for a multitude of neurological medical conditions.

The test uses a system of Rapid Number Naming which assesses the subject's ability to read aloud a series of numbers and determines their ability to discern levels of contrast. This test detects impairments of eye movements, language, attention, and overall neurological function and is validated down to an age of 5 years.

Null Hypothesis:

There is no measured difference in the return to baseline between the King Devick Test and the Trieger Dot Test in determining sedation recovery in non-neurological pediatric patients.

Material and methods

Subjects were recruited from the University of Iowa pediatric sedation clinic. The recruited subjects were children and adolescents between the ages of 6-17. No patients with a neurologic diagnosis were included in the study. Each patient performed both the KDT and TDT pre-sedation to establish a baseline. These tests were repeated once when the patient woke up (Post1) and again 20 minutes later (Post2). These tests did not interfere with clinical care, and the discharging physician was blinded to the results. After discharge, the family repeated both tests on the subject at home 24 hours post-sedation.

Results

A total of 41 patients were recruited for the study. Extraneous deviations for the TDT were compared to a total score for the KDT which summed the time and errors from all three cards. Baseline was established as baseline +/- 1/5(median change in score after sedation) to account for natural random variation. The results of the paired t-tests for KDT show that there is a highly significant difference between scores at baseline, Post1, and Post2 ($p < 0.001$). The p-values for the same tests for TDT were also all significant at the 5% level, however the difference between deviations at the Post2 after sedation is much less significant ($p = 0.04$). The results of McNemar's statistical test show no difference between the two assessments

at Post1 (p = 0.31), but a significant difference between the assessments at Post2 (p = 0.04).

0.018).

Conclusions

The paired t-test results show that the KDT, like the TDT, can measure differences in a patient's cognitive ability during recovery from sedation. Furthermore, McNemar's statistical test shows that at Post2 the TDT significantly classified more patients at baseline than the KDT. This corresponds with the results of the paired t-tests, in that more patients were close to baseline at Post2 for the TDT, than for the KDT. Overall, we can conclude that there is evidence that the KDT is more sensitive to impairment than the TDT, and if it were used in place of the TDT it would take more time for children to return to baseline after sedation.

Keywords

pediatrics, anesthesia recovery period, sedation recovery, King-Devick Test, rapid number naming, eye movements

Introduction

Post-anesthesia monitoring is based on careful, but subjective, observation of vital signs and neurocognitive status. The American Society of Anesthesiologists recommends that patients be released from the post-anesthesia recovery area once they are no longer at risk for cardiorespiratory depression [1]. However, these guidelines do not specify how a provider is to monitor the recovery of a patient's neurocognitive status. Anesthetic recovery is a complex progression that includes psychomotor, cognitive, and auditory processes. In pediatric anesthesia, recovery is vital to avoid developmental impediments. It is important for providers to quickly recognize a patient's poor recovery so that they can be treated and returned to a homeostatic balance before any physiological damage to the patient occurs [2]. Previous studies have evaluated the utility of psychomotor assessments to measure anesthetic recovery, including: mail box, manual dexterity, aiming, digital symbol substitution test, trieger dot test (TDT), pictoral recall, and auditory motor coordination studies [3]. The TDT is a well-validated measure of anesthesia and sedation recovery [3,4,5,6]. The TDT requires patients to connect dots placed 12 to 13mm apart. Variables measured are the number of dots missed and extraneous deviation (measured in mm) from the missed dots. Although the TDT and other psychomotor assessments objectively monitor anesthetic recovery, they are time consuming and are rarely used in the post-anesthesia recovery area. The King Devick test (KDT) is a well-validated test for concussion screening and monitoring. In addition to this, King Devick products have emerged as scientifically valid tests for a multitude of medical conditions such as: concussions, hypoxia, multiple sclerosis, amyotrophic lateral sclerosis, and Parkinson's disease [7,8,9,10,11]. The KDT uses a system of Rapid Number Naming which assesses the subject's ability to read aloud a series of numbers and determines their ability to discern levels of contrast. During the test patients read spaced numbers on a card line by line (Figure 1).

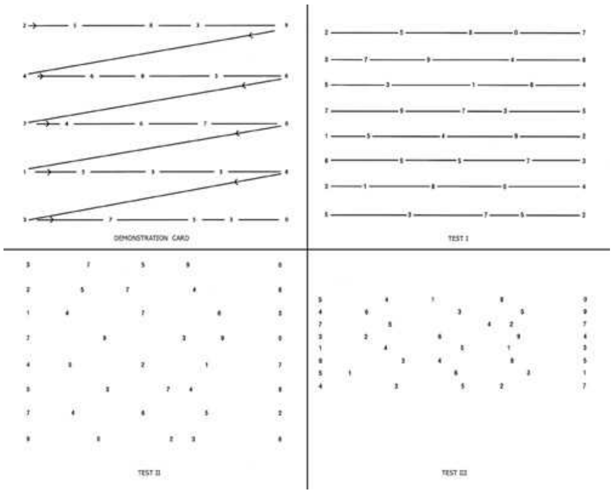

Figure 1. The King-Devick Test. Patients are asked to read each line as quickly as they can moving from right to left while the total time to complete and the errors made are recorded. The test includes three cards with increasing difficulty. *King-Devick Test® (K-D Test®)© 2019. Disclaimer: King-Devick Test card image is not to scale and for illustrative purposes only.*

There are three cards of increasing difficulty. Variables measured for KDT are time to complete, number of errors, and number of rows skipped. This system of assessment detects impairments of eye movements, language, attention, and overall neurological function and is validated down to an age of 5 years [12]. This study aims to determine if the KDT might also be a valid assessment for measuring post-anesthesia recovery.

Null Hypothesis:

There is no measured difference in the return to baseline between the King Devick Test and the Trieger Dot Test in determining sedation recovery in non-neurological pediatric patients.

Material and Methods

Subject Population:

Based on the operations of the University of Iowa pediatric sedation clinic and the time available to collect data, 41 subjects were enrolled in the study. The recruited subjects were children and adolescents between the ages of 6-17, including 21 female and 20 male patients. The average age of the patients was 11.9 with a standard deviation of 3.23.

The study did not include any patients with neurological diagnoses. Consent of parent/guardian and ascent of child was obtained prior to testing. The subjects assessed in this study underwent sedation for the following procedures: endoscopy (19), endoscopy and colonoscopy (10), lumbar puncture (6), MRI (3), bone marrow biopsy (1), radiation therapy (1), and peripherally inserted central catheter (PICC) line placement (1).

All subjections underwent sedation with the use of Propofol and Versed under UIHC pediatric anesthesia standard protocol.

Study Design:

Each patient performed both the KDT and TDT prior to sedation to establish their baseline. After the patient returned from their procedure, the tests were repeated once when the patient woke up (Post1) and then a second time 20 minutes after waking up (Post2). The total amount of time for the patients to perform both assessments took less than 5 minutes at each time point.

The assessments did not interfere with clinical care, and the discharging sedation physician was blinded to the results. After discharge, the family repeated both assessments on the subject at home 24 hours after the patient's procedure.

Statistical Analysis

Extraneous deviation was used as the variable of interest for the TDT because it reports both the frequency and severity of errors in that each dot missed has a minimum extraneous deviation of 1mm. For the KDT a one second penalty for each error and a five second penalty for each skipped row were added to the reading time to create a total summed score.

$$KDT\ Score = Time + Number\ of\ Errors + (5 * Number\ of\ Rows\ Skipped)$$

First, paired t-tests were performed on the KDT scores and the TDT extraneous deviations to determine if scores significantly changed after the sedation. Paired t-tests were calculated for each test separately comparing baseline to Post1, baseline to Post2, and Post1 to Post2.

Next, to assess if KDT and TDT were coming to the same conclusions we used McNemar's statistical test to determine if the patient's scores had returned "close" to their baseline.

McNemar's test is used on paired data to measure agreement between scoring. In statistical terms, we are looking at the marginal probabilities for each test and the null hypothesis is that these marginal probabilities are the same. In essence, McNemar's test is looking for consistency in returning to baseline between the two tests. Due to the natural random variation in a patient's score, it would be too strict to make a patient completely return to baseline. To account for this, *Close to baseline* was calculated as:

$$baseline +/- \sim 1/5\ (median\ change\ in\ score\ after\ sedation).$$

The median change for the first assessment after sedation for the KDT was 30.77, while the median change after sedation for the TDT was 14.00. 1/5th of these (after rounding to the nearest integer) is 6 sec for KDT and 3mm for TDT.

Thus, a patient was counted as returning *close to baseline* if their KDT score was within 6 sec of their baseline and if their TDT deviation was within 3mm of their baseline.

Results

The data distribution from the KDT at baseline, Post1, Post2 and 24 hours after sedation are shown in Figures 2 and 3. The data distribution from the TDT at these same intervals are shown in Figure 4.

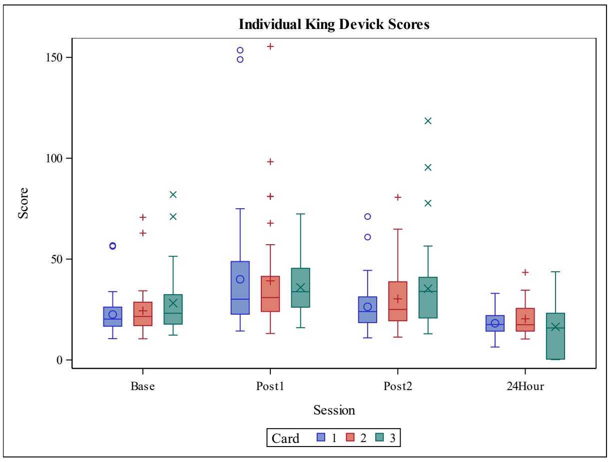

Figure 2. Distribution of KDT scores at each time point. *KDT – King Devick Test*

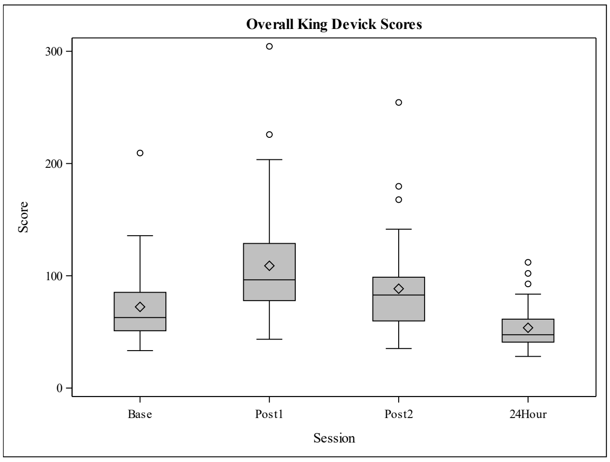

Figure 3. Distribution of KDT scores at each time point separated by card. *KDT – King Devick Test.*

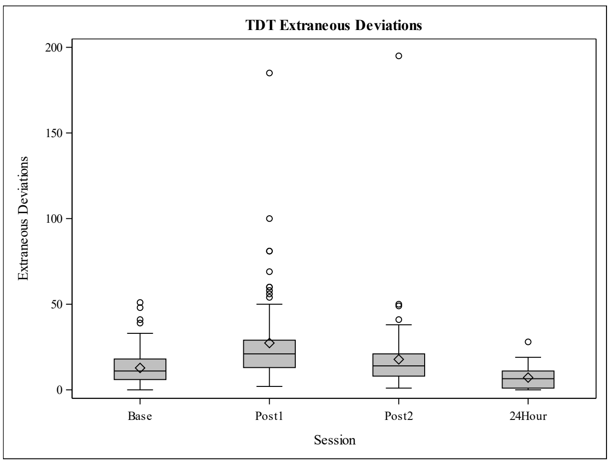

Figure 4. Distribution of TDT extraneous deviations at each time point. *TDT – Trieger Dot Test.*

Due to the unreliability of the take home data and the low response rate from patients, the 24 hour post test data was not used for analysis. The results of the paired t-tests for the KDT show that there is a highly significant difference between scores at all three time points (Table 1). The results for paired t-tests for the TDT were also all significant (Table 2). The difference between deviations at the second test after sedation (post2) is much less significant for the TDT (p=0.04) compared to the results for the KDT (p= <0.0001). McNemar's test was calculated at post1 and post2 to compare the KDT and TDT in assessing the patient's return to baseline. The proportion of patients that returned close to baseline at Post1 for KDT was 10% compared to 17% for TDT (Table 3). The results of McNemar's calculation at post1 showed no difference between the KDT and TDT (p = 0.31). In the second evaluation after sedation, the KDT classified 27% of patients as returning close to baseline while the TDT classified 51% of patients as close to baseline (Table 4). The results of McNemar's calculation at post2 show a significant difference between the KDT and TDT (p = 0.04).

	Difference in means	95% CI for mean	Standard Deviation	p-value
Post1 Base	36.6	(25.6, 47.6)	34.9	<0.0001*
Post2 Base	16.2	(10.9, 21.5)	16.9	<0.0001*
Post2 Post1	-20.4	(-31.0, -9.8)	33.5	0.0004*

Table 1. Paired t-test results for KDT total scores. *KDT – King Devick Test.*

	Difference in means	95% CI for mean	Standard Deviation	p-value
Post1 Base	21.6	(13.5, 29.7)	25.7	<0.0001*
Post2 Base	7.8	(0.3, 15.4)	24.0	0.0432*
Post2 – Post1	-13.8	(-19.9, -7.7)	19.3	<0.0001*

Table 2. Paired t-test results for TDT extraneous deviations. *TDT – Trieger Dot Test.*

Immediately Post Sedation	TDT		
KDT	Returned to "Baseline"	Not returned to "Baseline"	Total
Returned to "Baseline"	1	3	4 9.76
Not returned to "Baseline"	6	31	37 90.24
Total	7 17.07	34 82.93	41 100.00

Table 3. Cross classification of returning to baseline for KDT and TDT at post1. p=0.3173. *KDT – King Devick Test. TDT – Trieger Dot Test.*

20 Min Post Sedation	TDT		
KDT	Returned to "Baseline"	Not returned to "Baseline"	Total
Returned to "Baseline"	4	7	11 26.83
Not returned to "Baseline"	17	13	30 73.17
Total	21 51.22	20 48.78	41 100.00

Table 4. Cross classification of returning to baseline for KDT and TDT at post2. p=0.0412. *KDT – King Devick Test. TDT – Trieger Dot Test*

Discussion

The results of the paired t-tests show that both the KDT and TDT measure a difference in the patient's cognitive impairment between all three stages of testing. The patients performed significantly worse at the first assessment after sedation and then improved at the second test after sedation for both assessments. This shows that the KDT, like the TDT, is able to differentiate a patient's cognitive impairment while he or she recovers from sedation. Both assessments require establishing a baseline which takes time prior to the patient's initiation of sedation. However, when the patient is assessed after sedation the KDT is a structured and consistent test to quickly determine a patient's status.

In addition, a comparison of the baseline to post2 paired t-tests of the KDT and TDT suggests a difference between the two assessments. Although the TDT shows a significant difference between baseline and post2, the KDT shows a difference with much higher significance. This indicates that the KDT may be more sensitive in assessing cognitive impairment than the TDT as scores at post2 were further away from baseline.

This difference is also shown with McNemar's test calculations. While the calculation at Post1 shows no difference between the two assessments, the calculation at post2 shows that the TDT significantly classified more patients close to baseline than the KDT. This supports the results of the paired t-tests and implies that the KDT is more sensitive than the TDT in its assessment of cognitive impairment during sedation recovery for pediatric patients.

Limitations and Future Studies:

This study was limited by the poor response rate for 24 hour post sedation data and the lack of additional time intervals to evaluate the progression of recovery with both the KDT and TDT. Additional time intervals during the patient's hospital stay in this study were not possible due quick recovery after sedation. Including patients undergoing general anesthesia in future studies would give a longer time for recovery during which additional time intervals could be evaluated.

Furthermore, while each patient's sedation was performed with propofol and versed, there were some patient's that also received ketamine prior to sedation. This was not accounted for during the study and the patients were not differentiated between those who received this additional anesthetic and those who did not.

Finally, some limitations to using the KDT in the pediatric population were evident during this study. Although the study is validated to the age of 5, it was found that the younger patients had difficulty completing the assessment even when establishing a baseline prior to sedation. The main difficulty that these younger patients had was in the completion of the third (last) card of the test.

Conclusion

The KDT is a valid assessment tool in the evaluation of cognitive impairment for pediatric patients who receive sedation. In comparison to the TDT, a well validated measure of anesthesia and sedation recovery, the KDT may be more sensitive to cognitive impairment during sedation recovery. Further studies are needed to determine the validity of KDT for patients recovering from general anesthesia and its feasibility of use in clinical practice.

Compliance with Ethical Standards

This study was approved by the United States Institutional Review Board, 2017 June 13.

Disclosures

The author has no conflicts of interest to declare

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