The Efficacy of the Saline Load Test in Determining the Presence of Traumatic Arthrotomy of the Knee

Michael T. Orloff
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Abstract

Background: Lacerations and trauma are one of the leading reasons for visits to the Emergency Room. Treatment of a laceration depends on the location and complexity of the wound. When a trauma involves a joint (especially the knee), determining whether a laceration penetrates the joint capsule has been compromised is an important aspect of the diagnostic process. This review will evaluate the efficacy of the saline load test (SLT) in determining traumatic arthrotomy of the knee.

Methods: An exhaustive search of available medical literature was performed using Medline-OVID, Pubmed, American Academy of Orthopedic Surgeons (AAOS), Journal of Bone and Joint Surgeons, and Google Scholar using the keywords: laceration; trauma; joint capsule; saline load test; arthrotomy; knee. Studies were assessed for quality GRADE

Results: Six articles were reviewed for relevancy and validity. Two studies were chosen from the six based on eligibility criteria. One of the studies is a prospective study and the other a retrospective study; both studies evaluate the SLT as a diagnostic tool.

Conclusion: The SLT is an effective diagnostic tool for diagnosing traumatic arthrotomy of the knee. In order to achieve maximum specificity and sensitivity of the SLT the maximum amount of volume tolerated must be injected.

Keywords: Laceration; Trauma; Joint Capsule; Saline Load Test; Arthrotomy; Knee

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The Efficacy of the Saline Load Test in Determining the Presence of Traumatic Arthrotomy of the Knee

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Biography

[Redacted for privacy]
Abstract

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Acknowledgements

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Table I: Characteristics of Reviewed Studies and Summary of Finding
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List of Abbreviations

SLT...............................................................Saline Load Test
TAK.............................................................Traumatic Arthrotomy of the Knee
pw..............................................................=(- TAK)
I & D...........................................................Inspection and Debridement
ED.............................................................Emergency Department
AAOS......................................................American Academy of Orthopedic Surgeons
OR..............................................................Operating Room
MVC..........................................................Motor Vehicle Collision
The Efficacy of the Saline Load Test in Determining the Presence of Traumatic Arthrotomy of the Knee

BACKGROUND

Lacerations and superficial wounds are one of the top five reasons for emergency department (ED) visits to be treated as outpatient. Not all peri-articular injuries are traumatic arthrotomies but this possibility is on the differential diagnosis for every peri-articular laceration. The treatment is much different depending on the depth of the wound. If the laceration is a traumatic arthrotomy or penetrates through the joint capsule and into joint space the gold standard of treatment is much different than when the joint capsule is not compromised.

There are currently two different strategies for diagnosing traumatic arthrotomy with peri-articular wounds. The most common nonsurgical diagnostic tool is the saline load test (SLT). It is performed by injecting sterile saline into the joint an area away from the open wound. Extravasation of fluid from the would is indicative of traumatic arthrotomy. A negative SLT test would be the circumstance in which sterile saline is injected into the joint capsule to the desired amount and there is no extravasation of fluid. This indicates that the joint capsule is still intact and the trauma does not penetrate into the joint. The second diagnostic approach is where the provider conducts a thorough wound inspection is performed to search for a traumatic arthrotomy. If traumatic arthrotomy is then suspected an orthopedic surgeon performs an intraoperative inspection of the joint capsule.
Although the SLT is a widely accepted as the test of choice to diagnose traumatic arthrotomy of the knee and other joints, there is a lack of clinical evidence to support this as a diagnostic tool. This systematic review will specifically address using SLT as a diagnostic tool for identifying traumatic arthrotomy for and attempt to pinpoint at what volumes provide the highest specificity and sensitivity.

METHODS

An exhaustive search of available medical literature was performed using Medline-OVID, Medline-Pubmed, American Academy of Orthopedic Surgeons (AAOS), Journal of Bone and Joint Surgeons, and Google Scholar. All searches were conducted using the following keywords: laceration; trauma; joint capsule; saline load test; arthrotomy; knee. The search was then narrowed to include only studies published after 1995, written in the English language, and conducted on trauma patients and not on patients with iatrogenic lacerations of the joint capsule. Relevant articles’ bibliographies were also reviewed to expand the search. Studies were evaluated for quality using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE). 3

RESULTS

The initial result of the search yielded 425 articles. After screening all articles for relevancy six articles 2,4,5,6,7,8 resulted; however only two studies 2,5 fully met the eligibility criteria. The three studies 4,6,7 excluded evaluated iatrogenic arthrotomy of the knee and were therefore excluded. The two articles were a prospective study 5 and a retrospective review study. 2 See Table I.
VOIT et al

Is a prospective study\(^5\) of 50 patients with peri-articular lacerations with possible joint penetration over a 1-year time period at Legacy Emmanuel and OHSU Trauma centers. Forty of these patients had trauma to the knee, 4 to the elbow, 2 to the ankle, 2 to the wrist, and 2 to the interphalangeal joints.\(^5\)

Providers determined the likelihood of joint penetration on clinical grounds, these patients were then injected with 60 ml of sterile saline into the intracapsular space away from wound. A positive test was defined as extravasation of fluid from the joint capsule with either static or passive movement. A negative test was defined as distention of the joint without evidence of leakage to the point of increasing resistance or, in a conscious patient, to the point of discomfort. The results of these injections were then compared to the providers clinically based opinion. There was no mention of blinding of the individuals conducting the SLT to the providers clinically based opinion.\(^5\)

The data analysis showed that 36 patients had no leakage detected with the SLT. Of the 36 patients 14 of them where suspected to have joint penetration, making the error of clinical diagnosis 39%. The 14 patients that showed extravasations of fluid had 6 patients that had been judged to not have joint penetration on clinical grounds which indicates an error of 43%.\(^5\)

The Voit study has shown that clinical evaluation to determine if the peri-articular laceration has penetrated the joint is often incorrect. But the SLT is of value to assist in
the detection of joint penetration, because it detects a higher likelihood of predicting arthrotomy than compared to clinical judgment alone.\(^5\)

**Kondra et al**

This study\(^5\) conducted a retrospective review of 78 patients who underwent SLT of the knee in the ED and had a minimum of 14 days of follow up. They conducted the study to test the specificity and sensitivity of the SLT. Currently the gold standard is intraoperative inspection of the joint capsule and washout. If the SLT were to show high specificity and sensitivity patients could avoid going to the Operating Room (OR) for intraoperative inspection and would not have to endure with the comorbidities and risks associated with anesthesia and the operation.\(^2\)

The primary outcome was the rate of identifying arthrotomy by the SLT. A positive arthrotomy is indicated by a positive SLT or an infection with the assumption that all identified traumatic arthrotomies would develop a septic knee if there was no surgical intervention. The study retrospectively compared the results of positive and negative SLTs to the results of intraoperative inspection of the joint capsule and/or follow up evaluation for development of infection or complication of the knee joint.\(^2\)

Data was collected over a 3-year time period at a level 1 trauma center. The inclusion criteria included any patient who received an SLT during evaluation regardless of age and who had at least one follow up evaluation at a minimum of 14 days. Exclusion criteria were patients with an obvious arthrotomy because patients were taken directly to
the OR or patients that were lost to follow up. Of the 78 patients, 50 patients met the
criteria for the study.

The ED resident or physician performed the SLT. The test was performed using
sterile technique. An 18 or 21 gauge needle was placed into the joint capsule away from
the wound. Saline was then injected up to the maximum tolerated volume of the patient
or until the fluid began to extravasate through the knee wound. The knee was taken
through full ROM of flexion and extension of the knee.²

The results of the study were profound for the 50 patients observed, 34 men and
16 women. The mean volume of saline injected into the knee was 74.9 +/- 28.2 ml (40-
180ml). The majority of the wounds were to the anterior knee at 44%, lateral knee 26%,
medial knee 28%, and 1% to the posterior knee. Majority of injuries sustained were
gunshot wounds and falls with 14 patients in each, 5 patients were Motor Vehicle
Collision(MVC), 4 were motorcyle injuries, 4 stab wounds, 2 saw injuries, 2 pedestrians
were struck by sharp objects, 1 blunt trauma, and 1 was a dog bite.² See Table II

There was a total of 19 positive SLT. These 19 patients were then taken to OR for
visually confirm Traumatic Knee Arthrotomy (TKA). Of these 19 patients, 16 patients
had OR confirmation of the TAK. A total of 31 patients had a negative SLT. Of these 31
patients 30 patients remained negative for TKA in the 14 day follow up while one patient
had a septic joint and therefore a positive TKA. Given these results the SLT has a
sensitivity of 94% and a specificity of 91% to regards to evaluating the presence of TKA.
This results in a positive likelihood ratio (+LR) or 10.44 and a negative likelihood ratio (-
LR) of 0.07.² See Table III
DISCUSSION

The saline load test (SLT) is an effective test for the diagnosis of traumatic arthrotomy as demonstrated by both studies.\textsuperscript{2,5} The Voit et al study\textsuperscript{5} clearly illustrates that clinical inspection of the wound is not accurate in identifying TKA. Moreover, the Kondra et al study\textsuperscript{2} demonstrated a sensitivity of 94\% and specificity of 91\%. It is cost effective and decreases the risks and mortality associated with patients who have to go to the OR. The gold standard for traumatic arthrotomy diagnosing and treating has been for patients to go directly to the OR for Incision & Debridement (I&D) to avoid septic joints. This decision has been based on both clinical reasoning and the SLT. The SLT has been under utilized and used improperly by not using the proper volumes.

Voit et al\textsuperscript{5} first published their article in 1996 and his procedure changed the method of practice. This article helped show that SLT is more effective than clinical reasoning alone. This changed the standard of care, emergency rooms and trauma centers started using this test to diagnose TKA. The Voit et al\textsuperscript{5} study was an earlier study and the volumes used for the SLT were 60ml. The SLT at 60ml still altered care for 40\% of the patients when compared to clinical reasoning alone. This test was still effective but had its limitations. Some of the limitations of this study were the sample size, the volume test was static and didn’t compare different volumes, and there was not OR confirmation of TKA for both positive and negative SLT through intraoperative inspection or identification of infection when followed up, respectively.

The orthopedic and trauma surgeons community recognize the limitations of Voit et al study.\textsuperscript{5} Therefore, several other studies were conducted and published\textsuperscript{4,6,7} and tested
the SLT in other patients that were receiving elective orthopedic surgery. These studies\textsuperscript{4,6,7} tested iatrogenic lacerations of the knee and the appropriated volume needed to diagnose arthrotomy. From these studies\textsuperscript{4,6,7} the standard of care was changed to injecting the maximum amount of saline tolerated during the SLT. Volumes up to 175 ml were seen in these studies and showed the highest specificity of 99%.\textsuperscript{4}

The Kondra et al study\textsuperscript{2} then analyzed the utility of SLT for diagnosing TKA while injecting the maximum amount of saline in trauma patients with the lacerations that were non-iatrogenic. There are a couple of limitations with this study. The first issue is precision. This study has a small sample size. Another key differences in the Kondra et al study,\textsuperscript{2} from the Keese et al,\textsuperscript{6} and other such studies, is the size of the lacerations. The wounds of the Kondra et al\textsuperscript{2} study were fairly large (mean skin wound being 3.9 +/- 4.3 cm) and could lead to overestimating the diagnostic power of the SLT. If the size of the peri-articular wound is larger the assumption is that the arthrotomy is larger as well. With a larger arthrotomy the test can increase in specificity and sensitivity due to larger opening in the joint capsule. The size of the laceration has not been thoroughly studied, and it would be of importance in future studies to see if the sensitivity of SLT is dependent of the size of the peri-articular wound or laceration.

Further research should be conducted using larger sample sizes and comparing laceration size and accuracy of the test. Identify traumatic arthrotomies in patients with a negative SLT should be followed long enough to identify any complications related to missed TKA. Appropriately, The Kondra
et al study made the assumption that if a joint became septic with a negative test that it was TKA and was not properly diagnosed as an arthrotomy.

CONCLUSION

The SLT is effective, inexpensive, and safe approach in diagnosing TKA. This test shows the highest sensitivity and specificity when the maximum tolerated volumes were injected into the knee. This test allows for the diagnosis of TKA without taking patients to the OR. With high specificity it decreases the number of patients that are taken to the OR exposing fewer patients to the risks associated with anesthesia. After looking at these two studies the SLT should be the standard of care. There are several limitations of these studies and further studies should be conducted.
References


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<th>Studies</th>
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<th>Imprecision</th>
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<td>No bias likely</td>
<td>High</td>
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A) In the Voit there was no follow up. The SLT was conducted and if no extravasation then the test was - TKA  
B) Small sample size was 50 patients and the only outcome noted was extravasation. Since there was limited follow up there was no way to tell if the joint became septic or if other symptoms arose indicating TKA  
C) Small Sample size of 50 patients in the Kondra et al.
Table II

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<th>Age (yr)</th>
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<td>Amount of Saline injected (ml)</td>
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Table III

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