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The use of Kernig's and Brudzinski's sign in determining Meningitis: A Review

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Abstract

Objective: Assess the diagnostic value of Kernig's and Brudzinski's signs in determining meningitis among individuals aged 18 to 64. **Design:** Systematic literature review. **Methods:** Searches done in PubMed utilizing the terms Kernig and Brudzinski. In PubMed, studies were excluded if not in English, older than 2000 or done on animals, and meta-analyses. **Results:** Three studies were found including Nakao JH, et al, Thomas KE, et al, and Waghdhare S, et al. **Conclusion:** Kernig's and Brudzinski's signs have high specificity but yield a low sensitivity in determining meningitis. They are great tools to be utilized by medical providers, but only support the diagnosis of meningitis when positive.

Introduction

The use of Kernig's and Brudzinski's signs as part of the preliminary evaluation of meningitis is nothing new; it has been a bedside tool used by clinicians for over 100 years.[1] Meningitis is inflammation of the meninges that surround the brain and spinal cord. It can be caused by aseptic or bacterial organisms. Aseptic etiologies are typically self-limiting while bacterial causes are considered more of a medical emergency.[2] The symptoms of meningitis include headache, neck stiffness, nausea, vomiting, fever, chills, tachypnea, mental confusion, fatigue, and muscle and joint pain. These vague symptoms often mimic other neurological conditions. It is estimated that over 1.2 million individuals get diagnosed with bacterial meningitis worldwide every year.[3] If left untreated, there is mortality rate of up to 70%.[3] For those not among the estimated 135,000 people who die, there is around a 25% chance of developing permanent sequelae that include neurologic morbidity, hearing loss, or loss of a limb.[3] Thus, the most appropriate diagnostic methods must be employed to recognize the disease for rapid treatment to commence accurately. The well-established gold standard for diagnosing meningitis is lumbar puncture, which is more complicated and invasive when compared to bedside exams like Kernig's and Brudzinski's.

Kernig's sign is performed by flexing the hips and knees while the patient is in a supine position. Afterwards, the medical provider will gradually extend the knee. The sign is considered positive if there is inability of knee extension or if it elicits pain. Brudzinski's sign is also performed while the patient is supine and is done with passive flexion of the patient's neck. Brudzinski's sign is positive if the patient flexes their hips and knees as a result.[4]

Although it has become standard practice to teach these methods in medical model institutions, proper research is sparse and inadequate to get a true understanding of the efficacy

of its use. The resultative evaluations have been mixed and questionable at best. The sensitivity of Kernig's and Brudzinksi's signs is highly variable, whereas the specificity is consistently around the 90's. [1,5,6] Our analysis of the existing data aims to determine if the use of Kernig's and Brudzinski's signs is clinically useful and has adequate diagnostic value in determining meningitis among individuals aged 12 and up.

Patient Case

T.H. is a 25-year-old female presenting to the emergency room complaining of a sudden onset of fever, headache, neck stiffness, nausea and vomiting. During the physical exam, Kernig's and Brudzinski's signs were both negative. However, the patient had an altered mental status. The clinical provider is contemplating whether to continue with a meningitis workup to include head CT without contrast, lumbar puncture, CSF analysis culture, and empiric antibiotic treatment.

Methods

The research began in October 2021 utilizing PubMed with the search terms Kernig and Brudzinski. Limits were placed on articles that were "not in English, older than 2000, and study done on animals." This yielded 29 articles. Three promising studies looking at the diagnostic accuracy of Kernig's and Brudzinski's signs were identified (Figure 1).

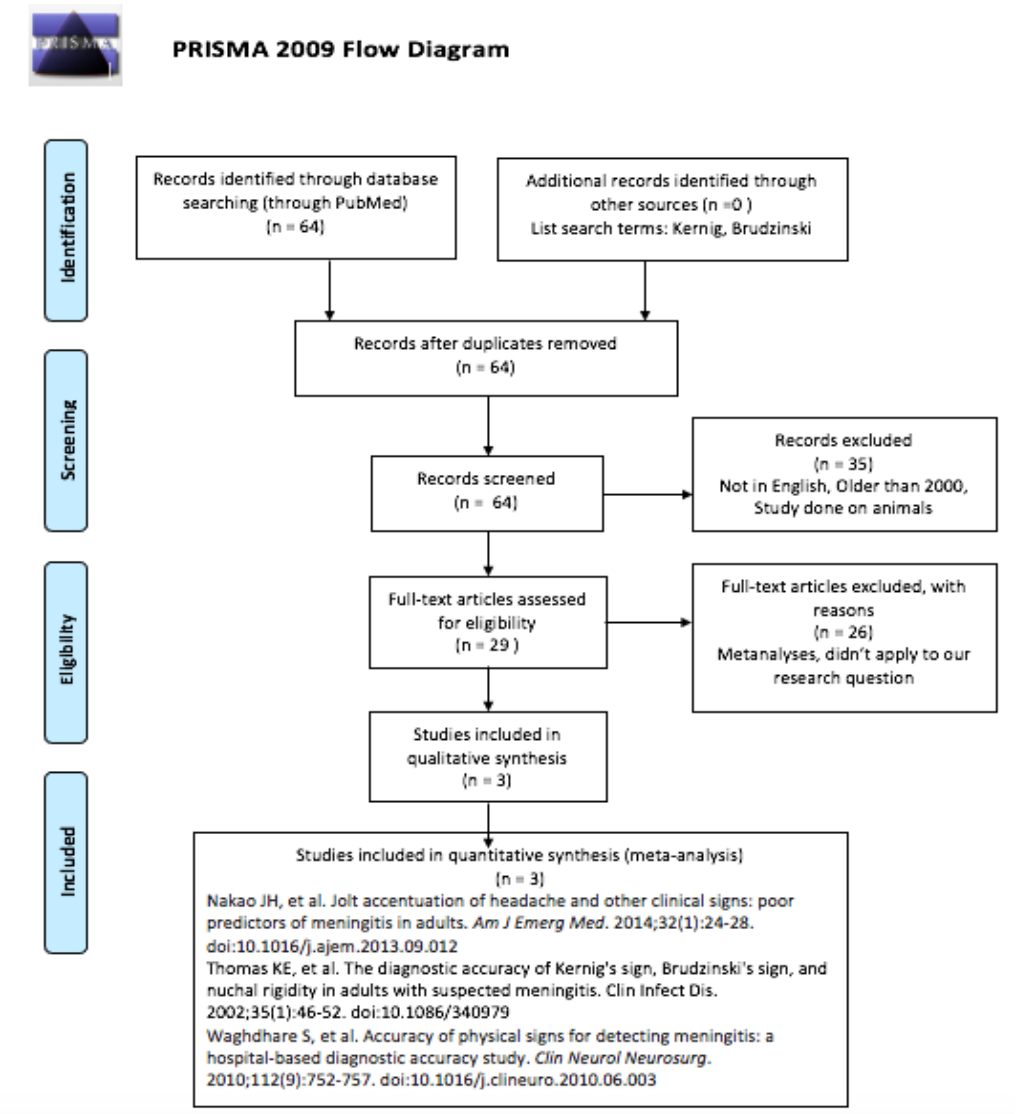

Figure 1: PRISMA Flow Diagram outlining database search that was carried out.

Results

Study #1: *Jolt accentuation of headache and other clinical signs: poor predictors of meningitis in adults. Nakao JH, et al.*

Study Objective:

To assess the sensitivity and specificity of clinical signs in detecting cerebrospinal fluid pleocytosis in patients undergoing lumbar puncture for suspected meningitis.

Study Design:

This was an observational study of 229 neurologically intact adult patients presenting to the academic ED of either St Luke's Hospital or Roosevelt Hospital in Manhattan, NYC, with symptoms suggestive of meningitis. Patients had to be 18 years or older and undergo a lumbar puncture due to suspicion of meningitis between January 1,

2006 and December 31, 2009. Patients with prisoner status, altered mental status, or the inability to consent were excluded from the study.

Throughout the three years, trained research assistants would approach physicians treating patients entering the ED with symptoms including headache and fever (≥100.4 ^{o}F) to inquire about the need for lumbar puncture. Additionally, lumbar puncture supplies were moved to the research assistant's kiosk to ensure patients undergoing lumbar puncture were caught.

After retrieval of consent, the patient's attending or senior resident would complete a standardized collection tool reporting the patient's age, sex, confirming the subjective symptoms of headache and fever, relaying the results of clinical signs including temperature, presence of Kernig sign, Brudzinski sign, jolt accentuation, nuchal rigidity, vomiting, and rash and assessing the clinicians level of suspicion (<50% probability or ≥50% probability) of meningitis before the lumbar puncture procedure.

Four tubes of CSF were obtained during a lumbar puncture. All CSF samples were sent to the labs, where the cell count, glucose level, protein level, and cultures were assessed. Pleocytosis was considered a white blood cell count greater than or equal to 5cells/HPF with a ratio of red blood cells to white blood cells less than 700:1. Moderate pleocytosis is defined as greater than or equal to 100 cells/HPF, and severe pleocytosis is defined as greater than or equal to 1000 cells/HPF.

Kernig sign was considered positive if the patient experienced hamstring pain or if the examiner met resistance while attempting to straighten the patient's leg passively with the hip flexed to a right angle. Brudzinski sign was considered positive if the patient flexed their hips secondarily to having their neck passively flexed. Nuchal rigidity was defined as pain or discomfort with neck flexion.

Statistical analysis was performed with 95% CIs for sensitivity and specificity or clinical signs.

Study Results:

The predictive capacity of the Kernig and Brudzinski signs in detecting pleocytosis and moderate pleocytosis are shown in tables 1 and 2. Nuchal rigidity results are used as a comparison. Of the 229 participants, 6 had a positive Kernig sign (2.6%), 5 had a positive Brudzinski sign (2.2%), and 43 had nuchal rigidity (18.8%). Both Kernig and Brudzinski signs were poorly sensitive but highly specific in detecting pleocytosis and moderate pleocytosis. The low sensitivity resulted in likelihood ratios suggestive that Kernig and Brudzinski signs are ultimately unhelpful in increasing clinical suspicion for meningitis.

Physician suspicion was found to have a sensitivity of 44% in patients with pleocytosis and 56% in patients with moderate pleocytosis.

Table 1. Predicting pleocytosis among subjects receiving LP				
	Sensitivity (0.95 CI)	Specificity (0.95 CI)	LR+	LR-
Kernig sign	2%	97%	0.8	1.0
Brudzinski sign	2%	98%	1.0	1.0
Nuchal rigidity	13%	80%	0.6	1.1

Table 2. Predicting moderate pleocytosis among subjects receiving LP				
	Sensitivity (0.95 CI)	Specificity (0.95 CI)	LR+	LR-
Kernig sign	7%	98%	2.9	1.0
Brudzinski sign	7%	98%	3.6	1.0
Nuchal rigidity	20%	81%	1.1	1.0

Study Critique:

Strengths include the method used to ensure capture of all patients undergoing lumbar puncture, the number of physical findings and symptoms that were compared together, including clinician perception, and the number of participants is comparable to other studies of this nature.

This study is hindered by the fact that emergency medicine residents as well as attendings were completing the examinations without ensuring proper and uniform technique, this fault could have led to a number of false negatives and/or positives for Kernig and Brudzinski signs.

Additionally, some subjects, but not all, consented to HIV testing. Through this screening, 8 patients were found to be HIV positive. Since HIV testing was not performed on all patients, the association of pleocytosis with immunodeficiency cannot be addressed.

Study #2: *The diagnostic accuracy of Kernig's sign, Brudzinski's sign, and nuchal rigidity in adults with suspected meningitis. Thomas KE, et al.*

Study Objective:

To determine the diagnostic accuracy of Kernig’s sign, Brudzinski’s sign, and nuchal rigidity for patients with suspected meningitis.

Study Design:

This was an observational study of 297 patients who presented to Yale-New Haven Hospital Emergency Department. Patients had to be older than 16 years and presented between July 1995 and June 1999 with suspected meningeal symptoms which may include fever, headache, stiff neck, photophobia, nausea and vomiting. If the patients met these criteria, they underwent a lumbar puncture. Four patients were excluded from the study due to head CT results that showed mass effect.

Prior to lumbar puncture, the clinical information was obtained and recorded by the ED physician or physician-investigator. The clinical information included complete history and physical exam findings such as Kernig's sign, Brudzinski's sign and nuchal rigidity. Physicians that were involved in conducting the physical exams were not given explicit instructions on how to conduct the meningeal exams.

CSF samples were analyzed for Gram staining, bacterial culture, WBC count, protein and glucose levels. The treating physician was able to order additional CSF analysis up to their discretion. The diagnosis of meningitis was given to those whose CSF WBC count was greater than or equal to 6 cells/mL.

Study Results:

CSF analysis revealed evidence of meningitis in 80 patients. Out of the 297 patients in the study, Kernig and Brudzinski sign was performed for 237 and 236 patients, respectively. There were seven patients who had a positive Kernig's sign while a different seven patients had a positive Brudzinski's sign. There were four patients who had both meningeal signs. Both tests were negative in the remaining patients. Out of the 11 patients who had a positive Kernig's sign, three patients had a positive CSF analysis for meningitis. Similarly, there were three patients that were diagnosed with meningitis out of the eleven patients who had a positive Bruzinski's sign (Table 3). Both Kernig's and Brudzinski's signs have a poor sensitivity but have a relatively high specificity (Table 4).

Table 3. Diagnostic accuracy of Kernig's and Brudzinski's signs

	(+) Meningitis	(-) Meningitis
(+) Kernig's Sign	3	8
(-) Kernig's Sign	63	163
(+) Brudzinski's Sign	3	8
(-) Brudzinski's Sign	63	162

Table 4. Sensitivity and Specificity of Kernig's and Brudzinski's signs				
	Sensitivity (0.95 CI)	Specificity (0.95 CI)	LR+	LR-
Kernig sign	5%	95%	0.97	1.0
Brudzinski sign	5%	95%	0.97	1.0

Study Critique:

A strength of this study is that it had a large sample size and had a consistent plan of action for the patients that have a high clinical suspicion of meningitis. All patients who had suspected meningitis underwent a lumbar puncture regardless of the presence of Kernig's and Brudzinski's signs.

A big downfall of this study was the potential inconsistency among the physicians and physician-investigators. Since there were no explicit instructions on how to perform the maneuvers or when to perform the maneuvers, it is possible that the tests were not conducted properly.

Study #3: *Accuracy of physical signs for detecting meningitis: a hospital-based diagnostic accuracy study. Waghdhare S, et al.*

Study Objective:

To determine the accuracy of using physical signs including nuchal rigidity, head jolt accentuation of headache, Kernig's, and Brudzinski's signs for detecting meningitis.

Study Design:

This was a double-blind, cross-sectional study performed at a rural teaching hospital on all patients who presented with acute encephalitis syndrome (AES) requiring lumbar puncture and CSF microscopy. Signs of AES included fever, headache, and altered mental status, with or without seizures or focal neurological deficit.

The study was conducted from May of 2008 to July of 2009, enrolling a total of 209 patients over the age of 12 who gave consent. ICU residents who participated in the study implemented the physical exam signs on each patient before their following lumbar puncture. Blind to the results of the physical exam, medical residents adequately trained on using a hemocytometer viewed the CSF sample for cell counting. The total time from physical exam to CSF cell counting was kept under 90 minutes; 60min from PE to LP and 30min from LP to cell count.

Meningitis was considered as greater than 5 white blood cells/μL of CSF. Signs of a traumatic lumbar puncture that included gross blood or a red blood cell count of >400cells/μl disqualified the patient from the study. Additional procedures of standard of care were performed in all samples under the direction of the treating physician.

Accuracy of the physical exam signs in diagnosing meningitis were based on "calculating sensitivity, specificity, positive and negative predictive values and positive and negative likelihood ratios." The individuals presenting with meningitis were subdivided into groups based on severity, main cell line in CSF, tertiles of GCS, and type of meningitis identified. Mild meningeal inflammation was considered CSF cells within 6-100/μL, while moderate and severe were 101-1000cells/μL and >1000cells/μL, respectively. Majority (75% cutoff) cell types included lymphocytes, neutrophils, and mixed. The study used diagti command in STATA in order "to calculate point estimates of accuracy and their 95% confidence intervals."

Study Results:

During the study, the number of participants were reduced from 204 to 190 due to exclusion from traumatic lumbar puncture. Of those remaining, 99 patients (52%) had CSF results that indicate meningitis. A comprehensive workup of those patients revealed aseptic meningitis in 62 (63%) of them, tuberculous meningitis in 30 (31%), and bacterial meningitis in 7 (7%). Out of the total 190 patients, only 17 (17%) had the classic signs of "fever, nuchal rigidity, and a change in mental status." When subdivided among severity of symptoms, 33 (17.3%) were mild, 50 (26.3%) were moderate, and 16 (8.4%) were severe. Overall, the use of any physical signs did not provide a meaningful or confident indication for meningitis regardless of stratification. Table 5 shows the data and statistical analysis of the diagnostic accuracy of using Kernig's and Brudzinski's signs for determining meningitis. Table 6 shows the values when subdivided among the degree of severity for meningitis. Neither positive nor negative likelihood ratios were statistically significant for both physical exams; however, a stratified set of results according to cell type in CSF and tertiles of GCS showed Kernig's sign being statistically significant with a large positive likelihood ratio (LR+ 5.57, 95% CI (1.83, 17)).

Table 5. Diagnostic accuracy of physical signs for determining meningitis

	Kernig's Sign		Brudzinski's sign	
	Positive	Negative	Positive	Negative
(+) Meningitis	14	85	11	88
(-) Meningitis	7	84	6	85
Numbers in parenthesis indicate 95% confidence intervals				

Sensitivity	14.1 (7.95, 22.6)	11.1 (5.68, 19)
Specificity	92.3 (84.8, 96.9)	93.4 (86.2, 97.5)
LR (+)	1.84 (0.77, 4.35)	1.69 (0.65, 4.37)
LR (-)	0.93 (0.84, 1.03)	0.95 (0.87, 1.04)

Table 6. Diagnostic accuracy of physical signs according to severity of meningitis

	Sensitivity	Specificity	LR+	LR-
Mild inflammation				
Kernig's Sign	6.1 (0.74, 20.2)	92.3 (84.8, 96.9)	0.79 (0.17, 3.6)	1.02 (0.91, 1.13)
Brudzinski's Sign	6.1 (0.74, 20.2)	93.4 (86.2, 97.5)	0.92 (0.19, 4.33)	1.01 (0.91, 1.11)
Moderate inflammation				
Kernig's Sign	24 (13.1, 38.2)	92.3 (84.8, 96.9)	3.12 (1.31, 7.42)	0.82 (0, 0.97)
Brudzinski's Sign	18 (8.58, 31.4)	93.4 (86.2, 97.5)	2.73 (1.03, 7.23)	0.87 (0.76, 1.01)
Severe inflammation				
Kernig's Sign	0 (0, 26.6)	92.3 (84.8, 96.9)	-	1.08 (1.02, 1.15)
Brudzinski's Sign	0 (0, 26.6)	93.4 (86.2, 97.5)	-	1.07 (1.03, 1.16)

Study Critique:

This study offered a unique perspective into the evaluation of physical signs for determining meningitis. Most studies that exist are retrospective, focused on an older subset of the population. Being a double-blind prospective study, the evaluators were able

to include participants who did not have meningitis but presented with similar clinical signs. Although being a teaching hospital, each medical resident trained in playing a role in evaluation was vetted and comparable to an experienced microscopist. Additionally, the age ranged from 13 to 81, with a mean of 38. Only 25 (13%) were over the age of 59. However, the variable age range can dilute the implications of the results for specific age groups like adolescents. The stratifications implemented and subsequent results of the study were also complementary to its strengths, specifically in regards to severity of meningeal inflammation and diagnostic accuracy of physical signs.

A noteworthy downfall in this study was its relatively small sample size that could be seen in a wide confidence interval. Many studies focus on bacterial meningitis when interpreting physical signs like Kernig's and Brudzinski's, however this study only had 3.6% of its participants in that particular subset. Interestingly, the article stratified test results according to types of cells in CSF and three quartiles of Glasgow coma scale but did not share the data, only commented on it.

Discussion

Meningitis is a common diagnosis made in the emergency room, and it is a critical finding that requires immediate intervention. Lack of prompt treatment can result in seizures, brain damage, hearing loss, permanent disability or death.[7] The use of clinical techniques as aides in early detection and diagnosis of meningitis is vital for positive patient prognosis. The purpose of this review is to determine if there is evidence in the literature to suggest that the use of Kernig's and Brudzinski's signs is beneficial enough as an adjuvant towards the final diagnosis of meningitis.

Although it has been implemented for many years, the research and evidence for the use of Kernig's and Brudzinski's signs is still unsatisfactory. From the data that we were able to compile, all the articles pointed to a potential strength in its specificity, however, a limitation in using these clinical signs to rule out the diagnosis of meningitis is its low sensitivity.[1,5,6] As a result, both the positive and negative likelihood ratios are uninformative. Tables 1 and 2 provide an overview of the three studies selected as well as their results. It is important to note that the sample size in each of these articles is relatively small and thus can have larger implications with the smallest of fluctuations.

It is, therefore, apparent that positive Kernig's and Brudzinski's signs only should be used to help rule in meningitis, and that its absence gives no substantive clinical value. The question then arises: Is a positive Kernig's or Brudzinski's sign even necessary or relevant given that other important clinical signs such as fever, stiff neck, and change in mental status would prompt a lumbar puncture for a definitive diagnosis regardless, given the seriousness and critical nature of the disease. Our current analysis on the research suggests: no.

Table 1. Overview of Studies			
	Nakao JH et al	**Thomas KE et al**	**Waghdhare S et al**
Patients, N	229	297	209
Location	Academic ED of either St Luke's Hospital or Roosevelt Hospital in Manhattan, NYC	Yale-New Haven Hospital Emergency Department	Rural teaching hospital
Study Type	Prospective Observational study	Prospective Observational study	Prospective Double-blind cross sectional study
Age Group	18+	16+	12+
Reference Standard	Same day lumbar puncture	Same day lumbar puncture	Same day lumbar puncture
Symptoms of interest	Headache and fever ≥100.4F	Fever, headache, stiff neck, photophobia, nausea and vomiting	Fever, headache and altered mental status, with or without seizures or focal neurological deficits
Diagnostic Pleocytosis	≥5 WBC/HPF	≥6 WBC/HPF	>5 WBC/HPF

Table 2. Overview of Results at Diagnostic Pleocytosis							
		Sensitivity (95% CI)	Specificity (95% CI)	LR+	LR-	PPV	NPV
Nakao JH et al	Kernig Sign	2%	97%	0.8	1.0	0.17	0.79
	Brudzinski Sign	2%	98%	1.0	1.0	0.20	0.79
Thomas KE et al	Kernig Sign	5%	95%	0.97	1.0	0.27	0.72
	Brudzinski Sign	5%	95%	0.97	1.0	0.27	0.72

Waghdhare S et al	Kernig sign	6.1%	92.3%	0.79	1.02	0.67	0.50
	Brudzinski Sign	6.1%	93.4%	0.92	1.01	0.65	0.49

Conclusion

In symptomatic individuals aged 12 or older, how accurate are positive Brudzinski's and Kernig's signs compared to the gold standard, lumbar puncture confirmation, as a detection tool for bacterial meningitis?

Kernig's and Brudzinski's signs are relatively quick physical exam maneuvers. When clinical suspicion for meningitis is high, it is best to proceed with a lumbar puncture regardless of the results of Kernig's and Brudzinski's signs. All three studies demonstrated that these signs were poorly sensitive in diagnosing meningitis in individuals aged 12 or older.[1,5,6]

Application to the Patient

All three of the studies in this review focused on symptoms similar to those that T.H. is currently experiencing; fever, headache, neck stiffness, nausea and vomiting. T.H.'s symptoms alone are suggestive of meningitis. Due to low sensitivity across all three studies, the negative Kernig and Brudzinski signs should not persuade the clinician from performing further tests, such as lumbar puncture. Positive Kernig and Brudzinski signs would also indicate a lumbar puncture for the purpose of obtaining a sample for definitive diagnosis and culture. Therefore, T.H. presenting symptoms alone would produce the same indications with or without the utilization of Kernig and Brudzinski signs.

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