Bedside Ocular Ultrasound for the Detection of Retinal Detachment in the Emergency Department

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Abstract

Objectives: Acute retinal detachments (RD) can be difficult to diagnose and may require emergent intervention. This study was designed to assess the performance of emergency department ocular ultrasound (EOUS) for the diagnosis of RD.

Methods: This was a prospective, observational study using a convenience sample of emergency department (ED) patients. Physicians performed EOUS for the diagnosis of RD prior to evaluation by an ophthalmologist. The criterion standard was the diagnosis of a RD by the ophthalmologist who was blinded to the results of EOUS.

Results: Fifteen physicians evaluated 48 patients with acute visual changes. Eighteen patients (38%) had RDs and all were correctly identified (true positives). Of the 30 patients (62%) without RD, 25 patients were correctly identified (true negatives), and five patients with vitreous hemorrhages were misidentified as having RDs (false positives). Therefore, the sensitivity and specificity of EOUS for RD were 100% (95% confidence interval [CI] = 78% to 100%) and 83% (95% CI = 65% to 94%), respectively.

Conclusions: Emergency department ocular ultrasound is sensitive for the diagnosis of RD and may have a role in excluding RD in patients presenting to the ED.

ACADEMIC EMERGENCY MEDICINE 2010; 17:913–917 © 2010 by the Society for Academic Emergency Medicine

Keywords: ultrasonography, retinal detachment

Retinal detachment (RD) is an ocular emergency that often requires immediate intervention to prevent rapid, irreversible visual loss.[1–3] Definitive diagnosis is made on dilated evaluation by an ophthalmologist, but patients frequently present first to the emergency department (ED). Classically, patients with RD complain of visual ''flashes'' and ''floaters,'' occasionally with monocular clouding or shadowing in a portion of the visual field,[1–3] but these complaints can also be associated with diabetic retinopathy or vitreous hemorrhages.[4] Likewise, while fundoscopic examination may reveal other findings such as hemorrhage or papilledema, fundoscopy can be difficult, especially in patients with cataracts or intraocular hemorrhages, making definitive diagnosis challenging.[5] Therefore, evaluation by an ophthalmologist is often required for definitive diagnosis, with some groups specifically recommending early referral to a retinal specialist.[6]

Ophthalmologists began using ocular ultrasound (US) in the 1950s[7,8] and have used it in the evaluation of RD since the 1970s.[9,10] Recently, ED ocular ultrasound (EOUS) has shown potential for diagnosing ocular pathology,[11] including RD.[12] The purpose of this study was to prospectively assess the performance of EOUS for the diagnosis of RD in ED patients with acute visual changes.

METHODS

Study Design

This was an institutional review board–approved prospective observational study of a convenience sample of patients between January 1, 2007, and June 30, 2008, when a participating physician was available to obtain informed consent and perform EOUS for RD prior to evaluation by an ophthalmologist. The study emergency

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Received October 27, 2009; revisions received January 2 and January 8, 2010; accepted January 11, 2010.

Presented at the AAEM National Meeting, Resident Research Competition, February 2009, resident research award, 3rd place.

Supervising Editor: Thomas G. Costantino, MD.

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doi: 10.1111/j.1553-2712.2010.00809.x
ISSN 1069-6563
PII ISSN 1069-6563583

physicians (EPs) were not the treating physicians and were blinded to all patient data until after the EOUS was performed and results were recorded on a predesigned data sheet.

Study Setting and Population

This study was conducted at an urban, academic ED with 49,000 annual adult visits, a postgraduate year (PGY)-2 through PGY-4 emergency medicine (EM) residency, and a PGY-1 through PGY-5 combined internal medicine/EM residency.

All patients presenting to the ED with acute (defined as less than 48 hours in duration) visual changes were eligible for participation if their treating physicians were obtaining consultation from the department of ophthalmology within 12 hours of presentation, and one of the participating EPs was available to perform EOUS for RD prior to the consultation. Patients were excluded if they could not speak English, were referred for ophthalmology consultation with a known diagnosis, or were unable to give informed consent.

All of the participating EPs completed an introductory course on emergency US during the first week of their PGY-2 year, received a 20-minute lecture-demonstration with examples of normal and abnormal ocular US examinations, and completed one proctored EOUS on a normal volunteer prior to enrolling patients in this study. The lecture-demonstration was done by an EP who was fellowship-trained in emergency US (TBJ).

There were 48 EPs eligible for participation (eight full-time faculty and 40 residents). Fifteen physicians volunteered to participate: two residents with < 10 prior US examinations, nine residents with 20 to 80 prior US examinations, two residents with 125 prior US examinations, and two attendings (see Table 1).

Study Protocol

Participating physicians, who were not the treating physicians and did not perform a fundoscopic examination on the patient, consented the patients and performed EOUS for the diagnosis of RD prior to evaluation by an ophthalmologist. The results were then recorded on a predesigned data sheet as showing either a ''retinal detachment'' or ''no retinal detachment.'' Research assistants, trained in data abstraction and blinded to the results of the EOUS examinations, then reviewed the results of the ophthalmology consultation for subsequent comparison.

Table 1
Final Hospital Diagnoses

Diagnosis	*n* (%)
Retinal detachment (15 atraumatic, 3 post–blunt trauma)	18 (38)
Diabetic retinopathy	8 (16)
Vitreal hemorrhage and detachment	4 (8)
Vitreal hemorrhage without detachment	4 (8)
Traumatic iritis	3 (6)
Acute glaucoma	2 (4)
Central retinal vein occlusion	2 (4)
Optic migraine	2 (4)
Central retinal artery occlusion	1 (2)
Expanding cerebral aneurysm	1 (2)
Optic lymphoma	1 (2)
Optic neuritis	1 (2)
Temporal arteritis	1 (2)

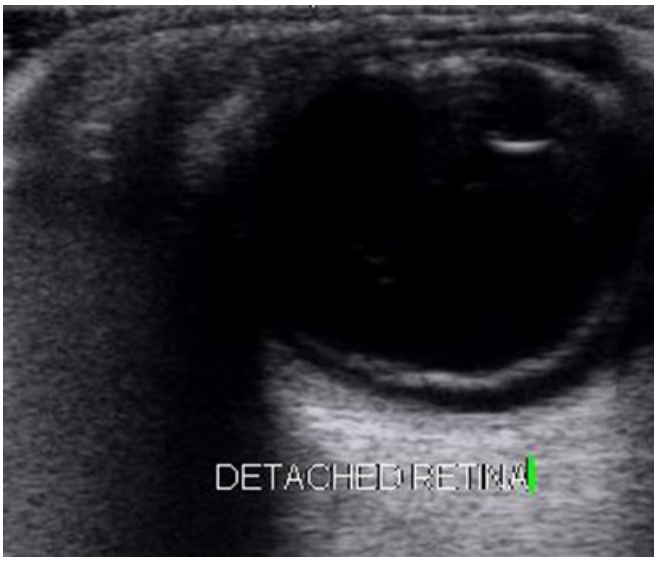

Figure 1. Example of retinal detachment seen on ocular ultrasound.

Emergency department ocular US was performed using either an Aloka SSD 1400 with a 7.5-MHz linear array probe (Aloka Inc., Wallingford, CT) or an Ultrasonix CEP with a 7.5-MHz linear array probe (Ultrasonix, Richmond, British Columbia, Columbia). The examination consisted of transverse or longitudinal views of the posterior chamber for the detection of an RD. An abnormal lifting of the retina or the presence of a retinal flap (Figure 1) was considered diagnostic of RD. The criterion standard for RD was the final diagnosis given by the ophthalmologist (either an attending or PGY-4 ophthalmology resident), who was blinded to the results of the EOUS. Postoperative surgical diagnosis was not used as the gold standard, since RD is not always surgically managed.[1–6]

Data Analysis

Data were collected in an Excel database (Microsoft Excel, Microsoft Corporation, Redmond, WA) and analyses were conducted using Stata, version 9 (StataCorp, College Station, TX). In a descriptive, secondary analysis, sensitivity and specificity calculations were repeated separately for physicians with more or less than 50 prior US examinations. This cutoff of 50 prior US examinations was chosen by consensus opinion of the authors as the minimum experience required to obtain the basic skills of bedside US. A power calculation was not performed because there were no prior studies to suggest what the sensitivity/specificity of EOUS might be for the diagnosis of RD.

RESULTS

During the enrollment period, 312 patients from the ED were seen by an ophthalmologist for acute visual changes of <48 hours duration, 78 of whom presented

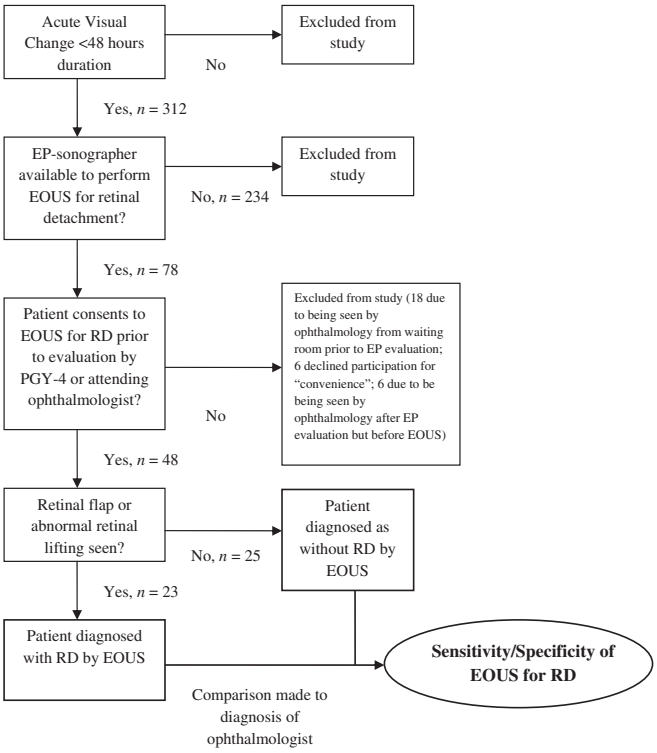

Figure 2. Study protocol. EOUS = emergency department ocular ultrasound; EP = emergency physician; PGY = postgraduate year; RD = retinal detachment.

when one of the participating EPs was available to perform EOUS (Figure 2). Thirty patients were excluded from participation: 18 due to being seen by ophthalmology from the waiting room prior to ED evaluation, six due to be being seen by ophthalmology after ED evaluation but before EOUS, and six due to declining participation for ''convenience'' reasons. Therefore, 48 patients were included in this study. There were 26 male (54%) and 22 female (46%) patients with an age range of 29–81 years (median age 56 years old). Twenty patients (42%) had diabetes, and six patients (13%) presented following blunt trauma to the face or eye.

Eighteen patients (38%) had an RD, all of whom were correctly identified by EOUS (true positives, Table 1). Twenty-five of 30 patients without RD were correctly identified as not having RD (true negatives). Five patients with vitreous hemorrhages without RD were misidentified with RD (false positives). Therefore, the sensitivity and specificity of EOUS for RD were 100% (95% confidence interval [CI] = 78% to 100%) and 83% (95% CI = 65% to 94%), respectively; the positive predictive value of EOUS was 0.78 (95% CI = 0.56 to 0.92), and the negative predictive value was 1.0 (95% CI = 0.83 to 1.0), with a positive likelihood ratio of 6 (95% CI = 2.7 to 13.4). When physicians who had previously performed more than 50 US examinations were compared to those who had performed ≤ 50 examinations, there was no difference (Table 2).

Twenty-three patients had B-mode ocular US done by ophthalmology on follow-up, utilizing a 10-MHz linear probe (16 with RD, five with vitreous hemorrhage, and two with diabetic retinopathy). Of the five patients with vitreous hemorrhage, four had complex vitreous detachments that were differentiated from RDs based on their location relative to the optic disk on US. Seventeen of the 18 patients with RD had subsequent procedural intervention by the department of ophthalmology. One patient refused procedural intervention.

Table 2
Data Stratified by Experience Level

Experience (No. of Prior Examinations)	True Positive	True Negative	False Positive	False Negative	Sensitivity, % (95% CI)	Specificity, % (95% CI)
1–50	7	6	1	0	100 (59–100)	86 (42–100)
>50	11	19	4	0	100 (72–100)	83 (61–95)

Operator	No. of Prior US Examinations	MD Level	True Negative	True Positive	False Negative	False Positive
1	>1,000	Attending	4	2	0	1
2	250	Attending	2	1	0	1
3	125	PGY-4	0	1	0	0
4	125	PGY-4	1	1	0	0
5	80	PGY-3	1	0	0	0
6	74	PGY-3	5	2	0	0
7	62	PGY-2	5	3	0	1
8	61	PGY-3	1	1	0	1
9	46	PGY-3	1	1	0	0
10	40	PGY-3	0	2	0	1
11	37	PGY-2	0	3	0	0
12	30	PGY-3	1	0	0	0
13	20	PGY-1	2	1	0	0
14	6	PGY-2	1	0	0	0
15	3	PGY-1	1	0	0	0

MD = medical doctor; PGY = postgraduate year; US = ultrasound.

DISCUSSION

Our findings suggest that EOUS would be most useful for excluding RD. The sensitivity and specificity of EOUS in our sample were comparable to that described previously for ocular US performed by ophthalmologists.[13] If confirmed by a larger, randomized trial, then EOUS may eventually be used to exclude the diagnosis of RD without ophthalmology consultation.

All of the misidentified patients had vitreous hemorrhages, four (80%) of whom had concomitant vitreous detachments, consistent with prior reports in the ophthalmology literature demonstrating a false-positive rate of 19% in the setting of vitreous hemorrhages.[13] Acute vitreous hemorrhages typically appear minimally echogenic on US, but can become more echogenic and appear thickened with time, thus mimicking the appearance of a RD.[14,15] On the other hand, a detached retina appears as a thick, often folded membrane that inserts into the optic disk.[14,15]

Vitreous hemorrhages can be differentiated from RD by three main characteristics. First, RDs localize to the optic disk (see Figure 3).[13,15,16] Second, while the probe is in place over the eye, patients are asked to shift their gaze from side to side.[16] In the setting of a vitreous hemorrhage, the echogenic line that occurs from the layering of blood will continue to remain horizontal, versus shifting with RDs.[16] Third, vitreous hemorrhages will often be seen in the middle portion of the posterior chamber, as opposed to RDs, which always occur at the posterior-most portion of the eye, closest to the optic disk and macula.[13,16] These three factors were not assessed by study physicians since they add complexity to the examination, which was presumed by the authors to be a prohibitive factor. This may have contributed to our false-positive rate. Future work should determine if EOUS that includes these factors would be more specific for RD without compromising its sensitivity.

It is significant that our data did not show a difference between operators with limited US experience and those with extensive overall US experience. This suggests that physicians with focused training could possibly acquire the necessary skills to perform EOUS quickly. However, our study was not powered to detect a difference based on operator experience, and this should be studied in a prospective fashion with more operators.

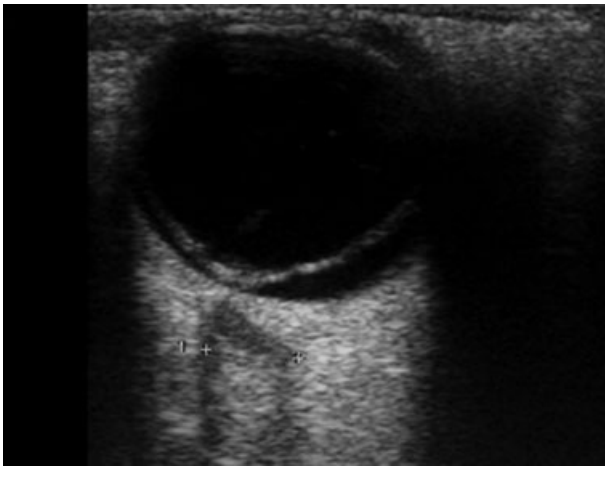

Figure 3. Retinal detachment seen relative to optic disk.

LIMITATIONS

There were only 48 patients enrolled. This was due to the availability of participating physicians and ED census and accounts for the wide CIs for the estimates of sensitivity and specificity.

Second, only 15 physicians volunteered for participation, likely representing an ''US-interest'' bias. These physicians were clearly interested in performing the examination and knew that their results were going to be compared to a criterion standard, raising the potential for a Hawthorne effect as well. Our findings may not apply to less interested physicians who do not believe that they are being ''tested'' or observed, since US is well known to be operator dependent.

Third, there is the possibility of disease spectrum bias. In our study sample, the prevalence of RD was quite high (38%), which could have enhanced the sensitivity of EOUS examinations. It is unclear how EOUS would perform in the general population, because prior work consists primarily of case reports rather than prospective studies, and similar studies in the ophthalmology literature involve samples of high-risk patients.[13]

Finally, as this was a study assessing the use of EOUS for the detection of RD, no attempt was made to compare EOUS to the physical examination or to assess if EOUS findings predict worse outcomes. We suspect that EOUS would add important information to the physical examination, especially in patients with cataracts or other conditions for which fundoscopic examination would be impaired, but this was not assessed and should be studied in the future. While the physical examination could lead to an interpretation bias when using EOUS, this was not assessed because the participating physicians did not perform fundoscopic examinations on the patients, nor were they aware of fundoscopic results.

CONCLUSIONS

Emergency department ocular ultrasound is sensitive for the diagnosis of retinal detachment and may have a role in excluding retinal detachment in patients presenting to the emergency department.

References

1. Haimann MH, Burton TC, Brown CK. Epidemiology of retinal detachment. Arch Ophthalmol. 1982; 100:289–92.
2. Ivanisević M, Bojić L, Eterović D. Epidemiological study of nontraumatic phakic rhegmatogenous retinal detachment. Ophthalmic Res. 2000; 32:237–9.
3. Li X; Beijing Rhegmatogenous Retinal Detachment Study Group. Incidence and epidemiological characteristics of rhegmatogenous retinal detachment in Beijing, China. Opthalmology. 2003; 110:2413–7.

4. Bhatia K, Sharma R. Eye Emergencies. In: Adams JG (ed). Emergency Medicine. Philadelphia, PA: Saunders Elsevier, 2008, p 219.
5. Fekrat S, MacCumber MW, deJuan E. Acute management of posterior segment injuries and emergencies. In: MacCumber MW (ed). Management of Ocular Injuries and Emergencies. Philadelphia, PA: Lipincott-Raven, 1998, p 300.
6. Vote BJ, Membrey WL, Casswell AG. Vitreous haemorrhage without obvious cause: national survey of management practices. Eye. 2005; 19:770–7.
7. Mundt GH, Hughes WE. Ultrasonics in ocular diagnosis. Am J Ophthalmol. 1956; 41:488–98.
8. Baum G, Greenwood I. The application of ultrasonic locating techniques to ophthalmology. Arch Ophthalmol. 1958; 60:263.
9. Kerman BM, Coleman DJ. B-scan ultrasonography of retinal detachments. Ann Ophthalmol. 1978; 10:903–11.
10. Blumenkranz MS, Byrne SF. Standardized echography (ultrasonography) for the detection and characterization of retinal detachment. Ophthalmology. 1982; 89:821–31.
11. Blaivas M, Theodoro D, Sierzenski PR. A study of bedside ocular ultrasonography in the emergency department. Acad Emerg Med. 2002; 9:791–9.
12. Elia J, Borger R. Diagnosis of retinal detachment in the ED with ultrasonography. J Emerg Med. 2008; 37:415–6.
13. Rabinowitz R, Yagev R, Shoham A, Lifshitz T. Comparison between clinical and ultrasound findings in patients with vitreous hemorrhage. Eye. 2004; 18:253–6.
14. Joseph DP, DiBernardo C, Miller NR. Radiographic and echographic imaging studies. In: MacCumber MW (ed). Management of Ocular Injuries and Emergencies. Philadelphia, PA: Lipincott-Raven, 1998, p 55.
15. Kumar A, Verma L, Jha SN, et al. Ultrasonic errors in analysis of vitreous haemorrhage. Indian J Ophthalmol. 1990; 38:162–3.
16. Jalkh AE, Avila MP, Hussein EM, et al. Immersion A- and B-scan ultrasonography: its use in preoperative evaluation of diabetic vitreous hemorrhage. Arch Ophthalmol. 1984; 102:686–90.