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Ultrasound characteristics of bruises and their correlation to cutaneous appearance

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ABSTRACT

Objective: The primary objective of this study was to compare the cutaneous size of a bruise on gross exam to the subcutaneous depth and height of the hematoma ascertained by ultrasound. The hypothesis was that there would be little correlation between the area of the bruise on cutaneous exam and the height when measured with ultrasound.
Methods: Adult and pediatric patients with bruising were prospectively identified in the emergency department. Photographs and ultrasound images were collected of the bruises and epidemiologic information collected from the patients. The cutaneous area of the bruise was compared with the sonographic characteristics.
Results: The subcutaneous depth and height of the hematomas defined by ultrasound did not correlate with the cutaneous area.
Conclusions: The cutaneous appearance of a bruise gives little indication of the depth and size of the subcutaneous bruise. Ultrasound can add information regarding these parameters.

1. Introduction

On average approximately three million cases of child abuse are reported annually in the United States [1] with nearly twenty percent of the proven cases to be physical abuse [2]. Studies also suggest that for every case of child abuse reported there are two to four cases that go unreported [1]. Abuse is most prevalent in children under the age of one year and more common in intellectually disabled children, populations which may have difficulty clearly describing the cause of their injury [2]. Despite the prevalence of child abuse, it often goes undetected in the medical setting [3]. There are many reasons for this; however, one barrier to diagnosis of abuse is the difficulty in distinguishing between abuse and accidental injuries. Like the skeletal survey, additional objective criteria to help diagnose and document an injury could be a valuable adjunct to the current paradigm.

The most common sentinel injury associated with physical abuse is skin disturbance, seen in up to ninety percent of physical abuse victims [4]. Therefore, skin abnormalities, such as bruises, are potential targets for developing objective clinical testing to distinguish these injuries as accidental or abusive. A bruise is defined as an injury producing a hematoma or diffuse extravasation of blood without rupture of the skin [5]. Often bruises are photographed for law enforcement, but this yields little information about the subcutaneous size and depth of the bruising, which may give some insight into the severity of the mechanism. Ultrasound has become widely available in many clinical settings, yet very little research has been performed evaluating the sonographic appearance of bruises. It is possible that this modality might give us an additional way to objectively document cutaneous injuries and assess the amount and type of inflicted force. The primary objective of this study was to compare the area of a bruise on gross exam to the subcutaneous depth and height of the hematoma ascertained by ultrasound. The hypothesis was that there would be little correlation between the cutaneous area of the bruise on gross exam and the subcutaneous depth and height when measured by ultrasound. A secondary outcome was to compare epidemiologic and historic information for sonographically visualized hematomas versus those not visualized by ultrasound.

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2. Materials and methods

2.1. Setting and patients

Adult and pediatric patients from a level one trauma emergency department were prospectively enrolled from June 2015 to August 2015. To be included in the study, patients required a visible cutaneous bruise acquired through any mechanism. Patients were excluded if they were not fluent in English or Spanish, if they had altered mental status (due to need for consent), or if they could not give a mechanism and time of onset of the bruise. Patients taking aspirin or non-steroidal anti-inflammatory drugs were included, but those on anticoagulants (Vitamin K, factor Xa, or direct thrombin inhibitors) were not. If a patient had multiple bruises, each bruise was included. Patient demographic and injury information were collected including height, weight, age, sex, time of injury, mechanism of injury, and modifying factors, such as medications and mobility since the injury. The study was approved by the Institutional Review Board and informed consent was obtained from each participant.

2.2. Data collection

After demographic information was obtained, each cutaneous bruise was measured in two dimensions and photographs were taken. Ultrasounds were performed in the emergency department during the patient's initial evaluation. Ultrasounds were performed by either a medical student who had been trained by an attending emergency physician, an attending emergency physician, or an ultrasound technologist. For the vast majority of cases, all three providers were present. Initial images were obtained with a 7–10 MHz linear array probe in two planes; however, the operator had the option of using a water bath or step-off pad for better superficial resolution, or using the 5–2 MHz curvilinear probe to visualize deeper structures. The area of the cutaneous bruise was scanned end to end to identify the deepest portion, and still images of this region were saved with calipers for measurements, as well as a video clip to confirm this represented the deepest portion. Sonographic evidence of a hematoma was defined as hypoechoic or anechoic changes within the subcutaneous tissue or muscle. While it is recognized that deep bruises can organize and parts can appear hyperechoic, there were no bruises in this study that contained a clear hyperechoic region, therefore only the hypoechoic or anechoic regions were measured.

2.3. Analysis

An RDMS-certified ultrasound fellowship-trained emergency physician reviewed each ultrasound image to evaluate the technique, confirm the presence or absence of a subcutaneous hematoma, and to verify the measurements. Inadequate studies were eliminated. The patients were divided into two groups: those with sonographic evidence of a subcutaneous hematoma and those without. The groups were compared for age, time from injury, mechanism of injury, location of bruise, and cutaneous size of bruise. The sonographic height (diameter of the bruise in the plane perpendicular to the skin) and depth of the hematoma (distance from the skin to the beginning of the bruise) were compared with the cutaneous area, calculated based on the assumption that the area of cutaneous bruise was ovoid. Fig. 1 demonstrates a representative ultrasound image with the relevant measurements.

2.4. Statistics

Data was compared using Fischer's exact due to the small size. Correlation was done using a parametric correlation coefficient.

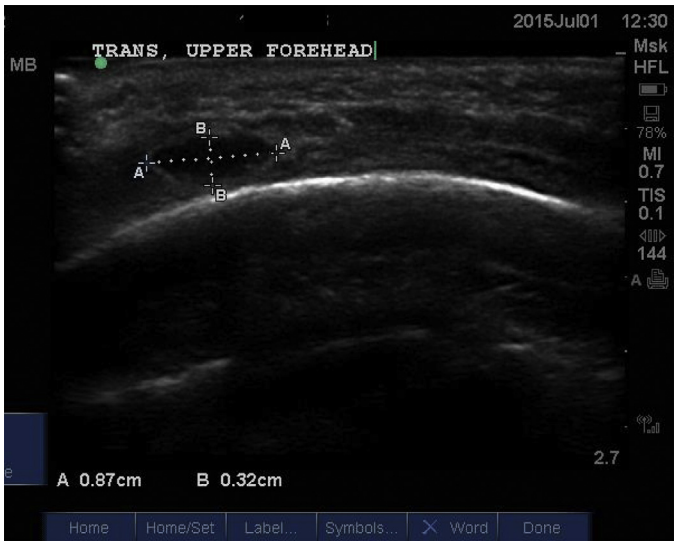

Fig. 1. Example of ultrasound bruise with diameter B representing height.

3. Results

Twenty-nine cutaneous bruises were studied. Two patients (three bruises) were excluded as it was discovered they were taking warfarin, and four more were excluded due to technical issues with proper acquisition or storage of adequate images (downloaded images did not clearly demonstrate at least one border of the bruise). This left 22 remaining cutaneous bruises in 18 patients for evaluation. In ten, the bruise could not be visualized with ultrasound. In the remaining 12 cutaneous bruises, a sonographic hematoma was identified and measurements were obtained. In the group without sonographic evidence of a subcutaneous hematoma, 80% were male, the average age was 38.7 years (range 1–95 years), and the average time from injury was 120.1 h (range 3–717 h). In the group with sonographic evidence of a subcutaneous hematoma, 83% were male, the average age was 43.9 years (range 11–76 years), and the average time from injury was 17 h (range 3–48 h) (Table 1). The patient age ($p = 0.266$) and cutaneous area of the bruise ($p = 0.266$) were not significantly different between the patients in whom a hematoma was visualized on ultrasound and those that were not visualized. The majority of patients in both groups were discharged home from the emergency department. While six bruises that presented prior to 2 days after the injury had no sonographic changes, no subcutaneous changes were visible on ultrasound when more than 2 days had elapsed between the time of injury and the ultrasound.

There was no association between the area of the bruise visible on gross exam and the depth of the injury determined by ultrasound (Table 2). The height of the sonographic hematoma

Table 1
Demographic information in patients with sonographically visualized and non-visualized bruises.

	Visualized bruise Mean (range)	Non-visualized bruise Mean (range)
Number	12	10
Age (years)	43.9 (11–76)	38.7 (1–95)
Gender (% male)	83	80
Time since injury (hours)	17 (3–48)	120.1 (3–717)
Cause of bruise (%fall/blunt trauma/vehicular collision)	67/17/17	50/30/20
Not/minimally active since injury (%)	91	60
Cutaneous area (cm^2)	19 (2.4–56.5)	29.7 (4.7–75.4)