Accuracy of Measurement of Hand Compartment Pressures: A Cadaveric Study

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Purpose To determine the accuracy of digital palpation for clinical assessment of elevated intracompartmental pressure compared with needle manometry in a simulated compartment syndrome of the hand.

Methods Three cadaveric hands were configured with interstitial fluid infusion and an arterial line pressure monitor to create and continuously measure intracompartmental pressure in the thenar and hypothenar compartments. Seventeen assessors clinically judged the presence or absence of compartment syndrome based on digital palpation for firmness and then measured pressures with a handheld manometer. An intracompartmental pressure threshold of 30 mm Hg or greater was used to diagnose compartment syndrome.

Results The sensitivity and specificity of digital palpation of the thenar eminence were 49% and 79%, respectively, with a positive predictive value (PPV) of 86% and negative predictive value (NPV) of 37%. Using the handheld manometer, the sensitivity and specificity increased to 97% and 86% with a PPV of 95% and NPV of 92%. The sensitivity and specificity of digital palpation of the hypothenar eminence were 62% and 83%, respectively, with improvement of 100% and 100%, respectively, with a handheld manometer. For the hypothenar compartment, use of a handheld manometer improved the PPV from 92% to 100% and the NPV from 40% to 100% compared with digital palpation.

Conclusions Digital palpation alone was insufficient to detect elevated compartment pressures in hands at risk for compartment syndrome. Handheld invasive pressure measurement was a useful adjunct for detecting elevated interstitial tissue pressures and may aid in diagnosing compartment syndrome. *(J Hand Surg Am. 2015;40(4):701−706. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Compartment syndrome, hand trauma, pressure monitor.

Compartment syndrome has potentially devastating consequences including loss of function, amputation, and death.[1−3] Accurate diagnosis of compartment syndrome is challenging and may be based on history and physical examination with the use of adjunctive techniques to measure compartment tissue pressure.[4−7] In obtunded or uncooperative patients, physical examination may be limited to palpation for tenseness of the muscle compartment as an adjunct to detecting elevated intracompartmental pressures. However, in the lower extremity, use of palpation to determine compartment tenseness, risk of compartment syndrome, and need for fasciotomy is unreliable.[7] A systematic review of the utility of physical examination findings in the diagnosis of compartment syndrome in the lower extremity noted that the absence of classic clinical findings (pain, pain with passive stretch, parasthesias, and paresis) often excluded the diagnosis of compartment

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Received for publication April 4, 2014; accepted in revised form December 2, 2014.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/15/4004-0009$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2014.12.003

syndrome but the low sensitivity of these findings made them less suitable in confirming the diagnosis of compartment syndrome.[8] Ultimately, the physician must make the diagnosis of compartment syndrome based on the overall clinical scenario, taking into account the patient's mechanism of injury, pain level, and physical examination findings. Adjunctive options such as invasive measurement of intracompartmental pressures may facilitate decision making.[1,5,9] These techniques initially required multiple pieces of equipment and diligent setup. The Stryker handheld manometer with a side-ported needle (Stryker, Mahwah, NJ) is one such device and was accurate in measuring intracompartmental pressures in *in vitro* studies.[10,11]

Although many manometers used in clinical practice determine intracompartmental pressure by measuring the pressure of a column of water in continuity with the muscle compartment, the accuracy of these readings may depend on the technique and type of terminal device used (straight needle, side-port needle, or wick catheter).[10–12] Although side-port needles and wick catheters may be more reliable than straight needles,[10,12] a study simultaneously measuring intracompartmental pressure with varying terminal devices found high accuracy in pressure measurement regardless of needle type.[11]

There are few studies on the accuracy of diagnostic criteria for compartment syndrome of the hand and forearm.[13–15] The goals of this study were to assess the clinical accuracy of diagnosing compartment syndrome by palpation and the accuracy of handheld manometer pressure measurements in the thenar and hypothenar compartment of the hand in a cadaver model for simulated compartment syndrome.

MATERIALS AND METHODS

Cadaver specimen setup

Three fresh-frozen cadaveric hand-to-elbow specimens were thawed to room temperature. We placed 2 18-gauge angiocatheters (Becton, Dickinson and Company, Franklin Lakes, NJ) percutaneously into both the thenar and hypothenar compartments of the hand. We used the thenar and hypothenar compartments for this study because they are readily palpable with the cadaveric hands placed palm up. Because of their anatomic variability and owing to difficulty in confirming and maintaining control pressures, we excluded the interosseous compartments from the study. For each compartment, one angiocatheter served as an inflow conduit for fluid and was connected to a pressurized 1-L bag of normal saline

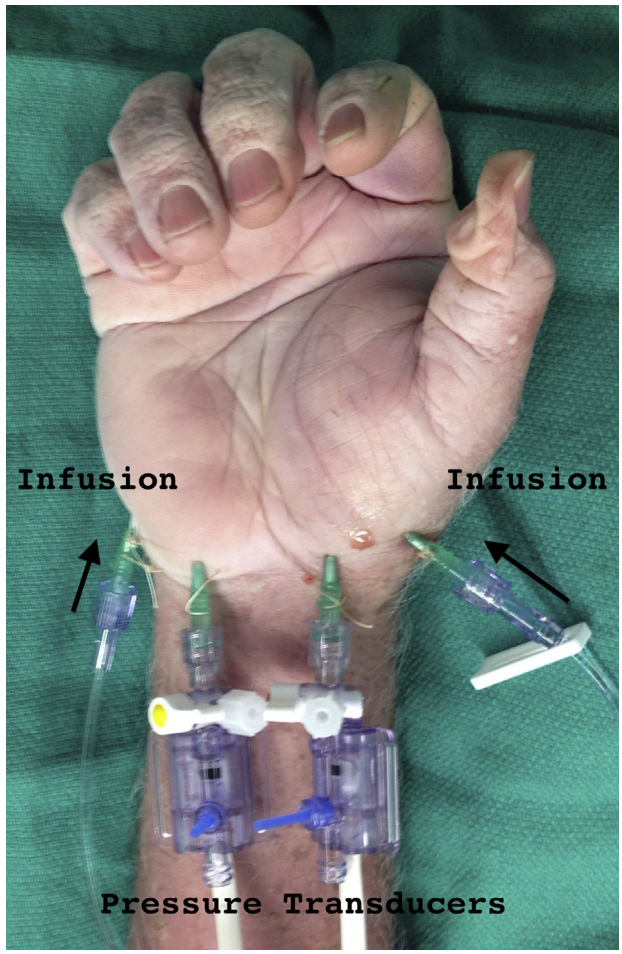

FIGURE 1: Experimental setup. Close-up of cadaveric hand with inflow and pressure monitoring angiocatheters placed into thenar and hypothenar compartments.

whereas a second angiocatheter was connected to an arterial line pressure transducer (TruWave disposable pressure transducer, Edwards Lifesciences, Irvine, CA) (Fig. 1). The 1-L bag of saline providing fluid inflow was placed into an inflatable pressure bag, which allowed for modulation of the inflow pressure. The arterial line pressure transducer was connected to a standard digital monitor system (ProPaq Encore, WelchAllyn, Skaneateles Falls, NY) that reported pressure with both waveforms and a numeric display. This setup has been previously validated to provide accurate pressure readings.[11] Accurate placement of the angiocatheters into the compartments was inferred by the ability to vary inflow pressure of fluid and subsequent visualization of a corresponding change in pressure on the arterial line monitor and by application of external pressure on the compartment resulting in generation of a pressure waveform on the monitor. The angiocatheter lines were sutured to the skin to prevent migration. Final confirmation of