Ulus Travma Acil Cerrahi Derg 2009;15(5):448-452
Klinik Çalışma

The role of the ankle brachial pressure index in the diagnosis of peripheral arterial injury

Periferik arter yaralanmalarında ayak bilek basınç indeksinin rolü

Mehmet KURTOĞLU, Kemal DOLAY, Burçin KARAMUSTAFAOĞLU, Hakan YANAR, Muharrem KUZKAYA

BACKGROUND

Angiography is the "gold standard" diagnostic tool for patients presenting soft signs of arterial injury. To reduce the number of unnecessary angiographies, we aimed to evaluate the role of the ankle brachial pressure index (ABPI) in the diagnosis of peripheral arterial injury in extremity trauma with soft signs.

METHODS

The data of 1772 patients with the suspicion of peripheral arterial injury was recorded prospectively. Two hundred eighty-three patients (16%) with any hard sign underwent immediate surgery. ABPI was calculated in 1489 patients with soft signs. Patients with ABPI <1 were evaluated by duplex ultrasonography and/or angiography, and if arterial injury was detected, the patients underwent surgery. Patients with an ABPI ≥1 were followed up conservatively.

RESULTS

1343 (90%) patients had ABPI ≥1; seven (0.5%) of them developed symptoms and signs of arterial injury and healed without morbidity. One hundred forty-six (10%) patients had ABPI <1; with DUS/angiography, arterial injury was detected in 39 of them (26.7%), and they underwent surgery. The sensitivity of ABPI <1 was 84.8%; specificity 92.6%; positive predictive value 26.7%; negative predictive value 99.5%; and overall accuracy 92.3%.

CONCLUSION

ABPI excludes arterial injury in 99.5% of patients with soft signs of arterial injury and avoids unnecessary examinations in 90% of patients. In the management of extremities with soft signs, ABPI measurement should be the first-line diagnostic choice.

Key Words: Ankle brachial pressure index; extremity trauma; peripheral arterial injury.

AMAÇ

Anjiyografi, şüpheli bulguların varlığında "altın standart" tanı yöntemidir; ancak, pahalı, uzun süren ve invaziv bir yöntemdir. Bu çalışmada, gereksiz anjiyografi sayısını azaltmak amacıyla, hızlı ve kolay uygulanabilir bir yöntem olan ayak bilek basınç indeksinin (ABİ) şüpheli periferik arter yaralanmalarının tanısındaki rolü araştırıldı.

GEREÇ VE YÖNTEM

Periferik arter yaralanması şüphesi olan 1772 hastanın verileri prospektif olarak incelendi. Fiziksel incelemede arter yaralanmasının kesin bulguları saptanan 283 (%16) hastaya acil cerrahi girişim uygulandı. Şüpheli bulguları olan 1489 (%84) hastanın ABİ hesaplandı. ABİ ≥1 olan hastalar konservatif takip edilirken, ABİ <1 olan hastalara dupleks USG ve/veya anjiyografi yapıldı. Arteriyel yaralanma saptanan hastalar ameliyata alındı.

BULGULAR

Şüpheli bulguları olan 1489 hastadan ABİ ≥1 olan 1343 (%90) hastanın 7'sinde (%0,5) takip sırasında erken dönemde arter yaralanması saptanarak cerrahi girişim uygulandı, morbidite gözlenmedi. ABİ <1 olan 146 (%10) hastanın 39'unda (%26,7) arter yaralanması saptandı. Şüpheli periferik arter yaralanmasında 1'in altındaki ABİ duyarlılığı %84,8; özgünlüğü %92,6; pozitif kestirim gücü %26,7; negatif kestirim gücü %99,5; tanı değeri %92,3 idi.

SONUÇ

Periferik arteriyel yaralanmaya ait şüpheli bulguların varlığında, ABİ ≥1 saptanması arteriyel yaralanmayı %99,5 oranında dışlar ve hastaların %90'ında ek tetkik yapılmasını önler. Bu hastalarda, ileri tetkiklere geçilmeden önce ABİ tercih edilecek ilk tanı yöntemi olmalıdır.

Anahtar Sözcükler: Ayak bilek indeksi; ekstremite travması; periferik arter yaralanması.

Department of General Surgery, Istanbul University, Istanbul Faculty of Medicine, Istanbul, Turkey.

İstanbul Üniversitesi, İstanbul Tıp Fakültesi, Genel Cerrahi Anabilim Dalı, İstanbul.

Correspondence *(İletişim):* Burçin Karamustafaoğlu, M.D. Atatürk Cad., Taşlıyol Sok., No: 28/20, Kadıköy 34734 İstanbul, Turkey.
Tel: +90 - 212 - 414 20 00 Fax *(Faks):* +90 - 212 - 635 85 22 e-mail *(e-posta):* burcinkaramustafaoglu@yahoo.com

Trauma is the first cause of death in people younger than 45 years of age. Vascular injuries comprise 3% of all civilian traumas and continue to have significant associated morbidity and mortality in the 21st century.[1] The causes of peripheral vascular injuries are penetrating wounds, blunt trauma and invasive procedures.[1] In the worldwide series, most of the arterial injuries are penetrating injuries.[1,2]

The presence of any of the hard signs of vascular injury (pulsatile bleeding, expanding hematoma, absent distal pulses, cold/pale limb, palpable thrill, audible bruit) mandates immediate surgical exploration and vascular repair.[3-6] Soft signs of arterial injury (history of severe hemorrhage, small and nonexpanding hematoma, anatomically related nerve injury, diminished pulse, and proximity of wound to major vessels) require additional diagnostic evaluation,[7] which points out that physical examination alone is often inadequate for accurate diagnosis of vascular injury.[5,8,9] Historically, routine exploration of the artery was performed even in the absence of hard signs.[10] In the 1950s, that aggressive approach was taken based on index of suspicion and proven to be effective.[10] This practice was popularized by Hughes and others but there was a significant negative exploration rate with associated morbidity.[11,12] The 1970s saw the increased use of arteriography to minimize the number of unnecessary wound explorations.[13] Arteriography has proven to be a very sensitive and specific test for diagnosing peripheral arterial injury.[10] Since contrast arteriography is expensive, time-consuming, potentially toxic, and rarely productive in the evaluation of injured limbs without obvious signs of vascular impairment,[14] different methods of screening have been used in the management of vascular injury over time, which include duplex ultrasonography (DUS), computed tomographic angiography (CTA) and magnetic resonance angiography (MRA).

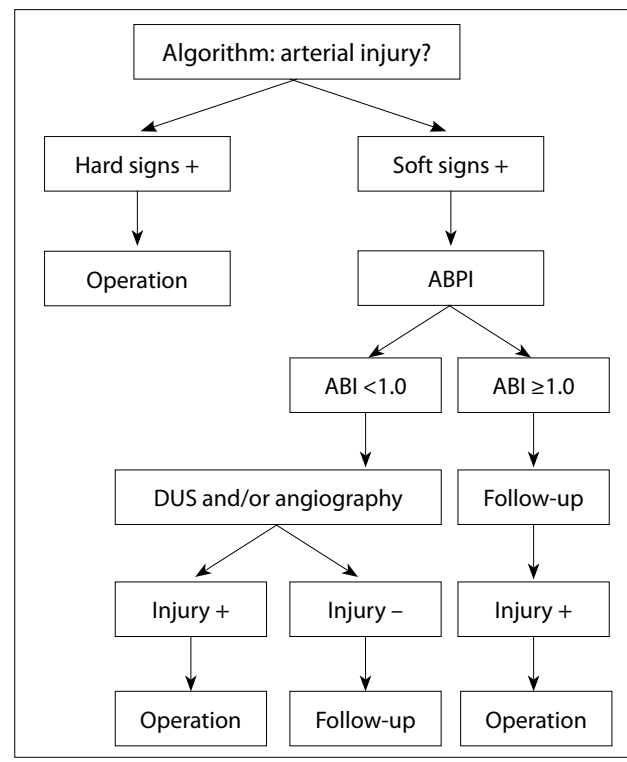
Studies about the use of the Ankle Brachial Pressure Index (ABPI), which is a very easy, rapid, simple, inexpensive, and non-invasive screening tool, have demonstrated that most of these invasive or non-invasive tests are unnecessary in the majority of patients. ABPI is the ratio of the ankle pressure of the injured extremity to the brachial systolic pressure.

The aim of this study was to evaluate the role of ABPI in the diagnosis of peripheral arterial injury in patients with extremity trauma with soft signs of injury.

MATERIALS AND METHODS

From January 1997 through January 2001, 1772 patients with extremity injury or with the suspicion of peripheral arterial injury admitted to our Trauma and Emergency Medicine Department. This observational study was recorded prospectively. When a hard sign of arterial injury [pulsatile bleeding, expanding hematoma, ABPI equal to zero (absent distal pulse), palpable thrill, audible bruit, and 6P signs (pain, pallor, paralysis, paresthesia, poikilothermia, pulselessness)] was present, the patient was directly operated. On admission, after the physical examination, ABPI was measured in all patients. Mini Dopplex Huntleigh Diagnostics Model D 900 was used to measure the index. Patients with soft signs of arterial injury (proximity of wound to major vessels, history of hemorrhage/shock, nonexpanding hematoma, diminished pulse, anatomically related nerve injury, and extremity fractures) were managed according to their ABPI score. Patients with an ABPI lower than 1 were evaluated by DUS and/or angiography, and if an arterial injury was detected, the patient underwent surgery. Patients with an ABPI of 1 or higher were followed up conservatively. In the follow-up, patients developing any symptom or sign of arterial injury underwent surgery (Table 1).

Table 1. The algorithm in the management of the patients with the suspicion of peripheral arterial injury



RESULTS

Of the 1772 patients, 1475 (83.2%) were male and 297 (16.8%) were female. Patients were from all age groups, and the mean age was 27.4. Nine hundred seventy-seven (977) patients (55.1%) had blunt and 795 patients (44.9%) had penetrating trauma.

Two hundred eighty-three patients (15.97%) had hard signs of arterial injury. They were all operated directly.

One thousand four hundred eighty-nine patients (84.03%) had soft signs of arterial injury and ABPI was 1 or more in 1343 patients (90.19%). They were all followed up conservatively. In the follow-up, seven of the 1343 patients (0.52%) with ABPI higher than 1 developed symptoms and signs of arterial injury in one month. Two of these patients had subintimal hematoma, were observed more closely and healed conservatively. Three of these missed injuries were false aneurysm of the deep femoral artery branches and they were threatened by angioembolization. The other two patients needed surgical reconstruction. One of the two surgical patients with missed popliteal arterial injuries readmitted with occlusion, and the other with a small false aneurysm of superficial femoral artery; these patients were operated successfully without morbidity.

One hundred forty-six of the 1489 patients (8.24% of 1772 patients) had ABPI lower than 1. DUS and/or angiography were performed in these patients. Arterial injury was detected in 39 of 146 patients (26.71%), and these patients underwent surgery (Table 2).

Table 2. Study population

	n	%
Gender		
Female	297	16.8
Male	1475	83.2
Age (years)		
<20	641	36.17
20-50	965	54.46
>50	166	9.37
Trauma		
Blunt	977	55.1
Penetrating	795	44.9
Total	1772	100

DISCUSSION

After the 1970s, routine arteriography was recommended in all cases when there was a high index of suspicion for blunt vascular injury in the presence of specific injury patterns.[10] However, the use of contrast angiography to exclude significant arterial injury is invasive, expensive,[15] time-consuming, potentially toxic,[14] and may cause puncture site complications, contrast nephropathy, allergic reactions, and vessel injury.[10] In addition, it is done mostly in radiology departments, and thus requires the transfer of the patient.[13,16] Furthermore, recent studies have repeatedly noted the paucity of positive arteriograms in patients with few or no signs of arterial disruption.[14] This experience, along with the emergence of other non-invasive testing modalities such as continuous wave Doppler, DUS, CTA and MRA led to the selective use of arteriography in cases where there is an indication of injury based on the initial non-invasive study.[10]

In the evaluation of arterial injury, DUS has been shown to demonstrate good sensitivity in comparison to gold standard angiography and operative exploration.[17-20] However, DUS is a highly operator-dependent examination and often technically difficult in trauma with surrounding tissue edema, hematoma, and associated fractures.[21]

Magnetic resonance angiography (MRA) demonstrates excellent visualization of vascular structure; however, for acute vascular evaluation, monitoring of critically ill patients within the magnet remains a major problem in practice.[22]

For these reasons, multi-slice helical computed tomographic angiography (MCTA) was used to detect arterial injury in the traumatized lower extremities and found to be a sensitive and specific non-invasive imaging modality for arterial evaluation of injured lower extremities.[21] However, MCTA is expensive, may cause allergic reactions and requires an educated staff, and contrast injection may have negative effects on the kidneys. MCTA is an improving technology for the management of arterial injuries.

Since ABPI is reliable in the quantitation of chronic arterial occlusive disease, Lynch and Johansen[14] hypothesized that it might be a potentially valuable screening tool in traumatic arterial injury management, and they demonstrated that the sensitivity and specificity of ABPI using continuous wave Doppler were very high. They declared that with arteriographic findings for comparison, ABPI lower than 0.90 had a sensitivity of 87% and a specificity of 97% for arterial disruption.

The investigators have found that when the involved extremity without clinical evidence of arterial injury has an ABPI or wrist-brachial index of at least 0.90, arterial injury is rare (negative predictive value for any arterial injury is 94% and 99% for arterial injury that requires operative repair).[23] The sensitivity of ABPI for prediction of arterial injury was 95% and specificity was 97%, although clinical follow-up has been suboptimal in patients with negative studies.[14,23,24] All had unpowered patient numbers.

The use of ABPI in the evaluation of patients who do not have hard clinical signs of arterial injury and performance of contrast angiography only in the patients with an index less than 0.90 may translate into significant cost and time savings.[23]

In our study with 1772 patients, those with hard signs (283 patients) underwent surgery directly, while the remainder with soft signs (1489 patients) were treated according to their ABPI. Patients whose index was 1 or higher (1343 patients) were followed up conservatively. From 1343 patients with index higher than 1, seven (0.5%) had arterial injury and only two (0.15%) of them required surgery. Patients with an ABPI lower than 1 were evaluated by DUS and/or angiography; arterial injury was detected in 26.7% of the patients. With this algorithm, there was no mortality, morbidity or organ loss associated with delay in the diagnosis, and 1336 patients with index higher than 1 were not subjected to any unnecessary "exclusion" arteriography. Our ABPI cut-off point was 1, with a 26.71% positive predictive value and 99.48% negative predictive value. In the literature, taking 0.9 as the cut-off point raises the positive predictive value with fewer unnecessary examinations, but increases the number of missed arterial injuries. Taking 0.9 as the cut-off point may be more cost-effective and acceptable since the missed injuries did not cause any morbidity or mortality. However, in our opinion, the ABPI level of 1 is safe for the first level elimination of vascular injury in the extremity trauma. This cut-off point does not cause any medico-legal problems and is very cost-effective.

Duplex ultrasonography can decrease the angiographic examinations in the hospitals when performed efficiently. On the other hand, the future of extremity vascular injury management may be with MCTA, but the literature evidence is not sufficient at present.

In conclusion, when there is a suspicion of arterial injury in a patient with an extremity trauma, ABPI is the first and the most efficient examination to exclude arterial injury and to avoid unnecessary invasive diagnostic examinations. It is also easy, inexpensive, quotable, and non-invasive.

REFERENCES

1. Compton C, Rhee R. Peripheral vascular trauma. Perspect Vasc Surg Endovasc Ther 2005;17:297-307.
2. Kurtoğlu M, Ertekin C, Bulut T, Belgerden S, Genç FA. Management of vascular injuries of the extremities. One hundred and fifteen cases. Int Angiol 1991;10:95-9.
3. Anderson RJ, Hobson RW 2nd, Lee BC, Manno J, Swan KG, Padberg FT Jr, et al. Reduced dependency on arteriography for penetrating extremity trauma: influence of wound location and noninvasive vascular studies. J Trauma 1990;30:1059-63.
4. Anderson RJ, Hobson RW 2nd, Padberg FT Jr, Swan KG, Lee BC, Jamil Z, et al. Penetrating extremity trauma: identification of patients at high-risk requiring arteriography. J Vasc Surg 1990;11:544-8.
5. Snyder WH 3rd, Thal ER, Bridges RA, Gerlock AJ, Perry MO, Fry WJ. The validity of normal arteriography in penetrating trauma. Arch Surg 1978;113:424-6.
6. Turcotte JK, Towne JB, Bernhard VM. Is arteriography necessary in the management of vascular trauma of the extremities? Surgery 1978;84:557-62.
7. Kurtoğlu M. Tanı yöntemleri ve genel yaklaşım. In: Ertekin C, Taviloglu K, Güloğlu R, Kurtoglu M, editorler. Travma. 1. basım. İstanbul: İstanbul Medikal Yayıncılık; 2005. s. 1169-1177.
8. Perry MO, Thal ER, Shires GT. Management of arterial injuries. Ann Surg 1971;173:403-8.
9. Levy BA, Zlowodzki MP, Graves M, Cole PA. Screening for extermity arterial injury with the arterial pressure index. Am J Emerg Med 2005;23:689-95.
10. Peck MA, Rasmussen TE. Management of blunt peripheral arterial injury. Perspect Vasc Surg Endovasc Ther 2006;18:159-73.
11. Jahnke EJ Jr, Hughes CW, Howard JM. The rationale of arterial repair on the battlefield. Am J Surg 1954;87:396-401.
12. Hughes CW. The primary repair of wounds of major arteries; an analysis of experience in Korea in 1953. Ann Surg 1955;141:297-303.
13. Applebaum R, Yellin AE, Weaver FA, Oberg J, Pentecost M. Role of routine arteriography in blunt lower-extremity trauma. Am J Surg 1990;160:221-5.
14. Lynch K, Johansen K. Can Doppler pressure measurement replace "exclusion" arteriography in the diagnosis of occult extremity arterial trauma? Ann Surg 1991;214:737-41.
15. Rose SC. Noninvasive vascular laboratory for evaluation of peripheral arterial occlusive disease. Part III--Clinical applications: nonatherosclerotic lower extremity arterial conditions and upper extremity arterial disease. J Vasc Interv Radiol 2001;12:11-8.
16. Gillespie DL, Woodson J, Kaufman J, Parker J, Greenfield A, Menzoian JO. Role of arteriography for blunt or penetrating injuries in proximity to major vascular structures: an evolution in management. Ann Vasc Surg 1993;7:145-9.
17. Bynoe RP, Miles WS, Bell RM, Greenwold DR, Sessions G, Haynes JL, et al. Noninvasive diagnosis of vascular trauma

by duplex ultrasonography. J Vasc Surg 1991;14:346-52.
18. Fry WR, Smith RS, Sayers DV, Henderson VJ, Morabito DJ, Tsoi EK, et al. The success of duplex ultrasonographic scanning in diagnosis of extremity vascular proximity trauma. Arch Surg 1993;128:1368-72.
19. Knudson MM, Lewis FR, Atkinson K, Neuhaus A. The role of duplex ultrasound arterial imaging in patients with penetrating extremity trauma. Arch Surg 1993;128:1033-8.
20. Zierler RE, Zierler BK. Duplex sonography of lower extremity arteries. Semin Ultrasound CT MR 1997;18:39-56.
21. Inaba K, Potzman J, Munera F, McKenney M, Munoz R, Rivas L, et al. Multi-slice CT angiography for arterial evaluation in the injured lower extremity. J Trauma 2006;60:502-7.
22. Yaquinto JJ, Harms SE, Siemers PT, Flamig DP, Griffey RH, Foreman ML. Arterial injury from penetrating trauma: evaluation with single-acquisition fat-suppressed MR imaging. AJR Am J Roentgenol 1992;158:631-3.
23. Johansen K, Lynch K, Paun M, Copass M. Non-invasive vascular tests reliably exclude occult arterial trauma in injured extremities. J Trauma 1991;31:515-22.
24. Meissner M, Paun M, Johansen K. Duplex scanning for arterial trauma. Am J Surg 1991;161:552-5.