Vascular lesions associated with bicruciate and knee dislocation ligamentous injury

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KEYWORDS
Knee; Dislocation; Multiligament knee injury; Vascular lesions

Summary
Introduction: The incidence of associated vascular lesions in biligamentous cruciate injuries of the knee ranges from 16 to 64\%, with a mean rate of 30\%. Treatment of ischemic vascular lesions associated with ligaments injury is well established, comprising emergency arterial vascular repair, most of the times combined to external fixation. In the absence of clinical symptoms of vascular lesion, some authors recommend systematically performing arteriography, while others advocate selectively prescribing this examination in doubtful clinical situations. The present study analyzed data extracted from the prospective series of the 2008 SOFCOT Symposium (dedicated to management of bicruciate knee lesions) and from an analysis of the literature, with emphasis on developing a diagnostic strategy for vascular lesions associated with bicruciate lesions.

Material and methods: This multicenter prospective study included all patients treated in the reference centers for dislocation or bicruciate lesion of the knee between January 2007 and January 2008. All patients underwent early objective vascular imaging.

Results: Sixty-seven patients were included. Mean dislocation reduction time was 2 hrs 45 min (max, 21 hrs). There were nine vascular lesions (12\%). Absence of vascular lesion could be
confirmed in 58 of the 59 patients exhibiting presence of peripheral pulses at initial examination. In one case, a vascular lesion was found on early imaging, but with no clinical consequence. In all eight cases with associated clinical pulse abnormality, complementary vascular check-up confirmed the presence of a vascular lesion. Angioscan induced no error of vascular assessment in this series, with no false positives or false negatives. One patient underwent amputation for critical ischemia. Three patients had vascular surgical treatment, two not undergoing secondary ligament surgery. Four of the five patients whose vascular lesion was conservatively managed by simple observation were able to undergo the scheduled treatment for their ligament lesions.

Discussion: At initial examination, it is essential to look for the peripheral pulse. In case of ischemic syndrome, the priority is a revascularization procedure associated to intraoperative arteriography. In case of abnormal pulse without obvious ischemia, emergency imaging (usually arteriogram or angioscan) is essential. Where there is no initial clinical vascular abnormality, good practice is less clearly cut. Initially, present pulses are found in a mean 30% (17—55%) of cases of popliteal artery lesion, according to the series. Different authors draw diverging conclusions from this fact. For some, the absence of frank abnormality on clinical examination is sufficient to exclude not any possible anatomic vascular lesion but any vascular lesion requiring surgery. However, even without pulse abnormality, we consider systematic imaging to be justified, partly by the difficulty of ensuring strict monitoring, and partly by the decompensation risk of clinically asymptomatic intimal lesions during the ligament surgery under consideration in most cases. Although many authors cling to the dogma of late emergency arteriography, recent reports argue against this attitude. Anglo-MRI has good diagnostic value, but in practice is difficult to obtain in emergency. We would rather advocate angioscanning, which is easily available in emergency and does not incur the risk of local complication associated with arteriography.

Type of study: Prospective continuous. Level IV.

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Introduction

The incidence of vascular lesions associated with bicruciate lesion of the knee is between 16 [1] and 64% [2], with a mean estimated at 30% by Hegyes et al. [3]. This incidence can be explained by the anatomy of the popliteal artery, which is fixed at both extremities — in the hiatus of the great adductor tendon (Hunter’s canal) above, and the soleus muscle arcade below — so that the high energy movements involved in such trauma endanger this artery in which movement is restricted [4].

Treatment of ischemic vascular lesions associated with ligament lesion is well codified [5]. Only emergency vascular repair, generally with associated external fixation, can reduce the risk of amputation. The present rate of residual amputation is 10% [6,7]. Any delay in revascularizing the lower limb puts it in jeopardy. Green and Allen [8] reported an amputation rate reaching 86% in case of delay exceeding 8 hours. This highlights the need for good coordination in the management of these patients.

Good practice in the absence of any symptomatic vascular lesion is controversial. For some, “there is a vascular lesion unless proved otherwise”, and this attitude is defended by two arguments. On the one hand, there are reports of complete popliteal artery lesion with normal peripheral pulse on initial examination [9,10,11]; the collateral arterial vascularization of the knee may be able to maintain peripheral pulse initially, but is not an adequate substitute for the popliteal artery [12]. On the other hand, anatomic lesions are often intimal lesions that may induce secondary ischemia by clotting around the intimal flap [13,14]. For these two reasons, systematic lower-limb arteriography has been recommended in all patients with bicruciate lesion of the knee [11,15,16]. Miranda [17] and Abou-Sayed et al. [18], on the other hand, recommend arteriography only on clinical suspicion of vascular lesion; they report good correlations between clinical findings and arterial lesions, with lower-limb salvage rates equivalent to those achieved with systematic arteriography.

The present study was based on data from the prospective series of the 2008 SOFCOT Symposium on the management of bicruciate lesion of the knee and on an analysis of the literature. The aim was to develop a diagnostic strategy for vascular lesions associated with bicruciate lesions, addressing the following questions:

- What organizational strategy can optimize the treatment of vascular lesions associated with bicruciate lesions of the knee?
- What value do the clinical and paraclinical examinations have for assessing vascular status?
- Should imaging be systematic?
- If so, should it be arteriography or some other examination?

Material and methods

This was a multicenter prospective study. All patients treated for bicruciate knee lesion, with or without dislocation, between January 2007 and January 2008 in the study centers were included. Data were recorded on a dedicated form and analyzed with the help of a specialized statistics and epidemiology team. As the number of patients showing vascular lesion was small, only descriptive statistics were applied.

Vascular assessment systematically comprised pulse taking at initial treatment, after reduction if necessary, and
Table 1  Details of the nine patients with an anatomical vascular lesion.

<table>
<thead>
<tr>
<th>Case</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>Fall</td>
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<td>Immediate</td>
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<td>3</td>
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<td>Time to reduction (hrs)</td>
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<td>0.5</td>
<td>2</td>
<td>Immediate</td>
<td>1</td>
<td>3</td>
<td>&gt; 24 h</td>
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<td>PBL</td>
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<td>RB</td>
<td>CLB</td>
<td>RB</td>
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<td>NP</td>
<td>Asym</td>
<td>NP (portable Doppler +)</td>
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<td>Sym</td>
<td>NP</td>
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<tr>
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<td>Asym</td>
<td>Sym</td>
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<td>ND</td>
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<td>No</td>
<td>CPN</td>
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<td>Amputation</td>
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</tr>
<tr>
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<td>—</td>
<td>—</td>
<td>6</td>
<td>&gt; 8</td>
<td>—</td>
<td>26</td>
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</table>

PT: previous popliteal thrombosis; T2D: type II diabetes; RA(M): road accident with motorcycle; RA(O): other road accident; SR: knee dislocation with spontaneous reduction; Immediate: knee dislocation reduced by accident witness; CMB: combined medial bicruciate lesion; CLB: combined lateral bicruciate lesion; IBC: isolated bicruciate lesion; RB: rotational bicruciate lesion; NP: no pulse detected; Asym: asymmetric pedal pulses; NA: not available; ND: not done; AN: abnormal; MP: medial popliteal lesion; DP: distal popliteal lesion; CPN: common peroneal nerve; Medical: medical treatment using anticoagulant drugs; endovasc: endovascular surgery; Surg: ligament reconstruction before 45 days post-trauma; Late Surg: Ligament reconstruction after 45 days post-trauma; ExtF: External fixator; PBL: posterior bicruciate lesion; ATCD: antecedent.
ankle abnormality, Doppler examination (portable or not) was available. All patients, whatever their vascular status, systematically underwent objective imaging comprising, depending on center availability, arteriography, angio-MRI or angioscan; in some cases, more than one technique was applied. Analysis of the series was completed by a review of the literature.

Results

Sixty-seven patients were included. Lesion mechanism could be specified in 59 patients: high energy trauma in 68% of cases, and low energy trauma in 32%. There were 44 cases of true knee dislocation (65.7%) and 15 (22.3%) of bicruciate knee lesion without dislocation; in eight cases (12%), the reality of the dislocation could not be determined.

Time to treatment in case of dislocation could be analysed in 41 cases, with a mean of 2 h 45 min (range, 0 to 21 hrs). In four cases of secondary transfer, transfer time exceeded 24 hrs. In 22 of the 44 cases of dislocation, it had not been reduced after transfer.

Vascular status was assessed in all 67 cases, as was peripheral pulse. The ankle-angle index was measured in less than 50% of cases. Nine vascular lesions were found (12%), all associated with true dislocation (Table 1).

In 59 cases, initial clinical examination found no abnormality in peripheral pulse. Objective imaging comprised 11 arteriograms, seven angio-MRIs and 44 angioscans, and confirmed the absence of vascular lesion in 58 cases, while one clinically silent vascular lesion was detected on angioscan. When several imaging techniques were applied, results were coherent, indicating the absence of vascular lesion.

In eight cases, there was initial clinical pulse abnormality. Three, including two rapidly reduced true knee dislocations, consisted in simple asymmetry; in the other five, associated with true knee dislocation not reduced at emergency admission, the pulse was initially imperceptible. Imaging used angioscan in six cases, arteriography in one case, and angioscan plus arteriography in one case. In all eight cases, overall imaging results confirmed the vascular lesion.

Regarding treatment, one patient with severe cranio-cerebral trauma contraindicating anticoagulant treatment underwent amputation for critical ischemia on admission, after reduction 3 hours post-trauma before transfer. Two patients had vascular repair using resection graft, respectively 6 and 26 hours post-trauma. One patient underwent endovascular surgery at 13 hours post-trauma. The other five patients could not be operated on, but were treated by a curative dose of anticoagulants and clinical surveillance. Two of the three patients operated on for the vascular lesion did not undergo secondary ligament surgery; the third, treated by resection graft, underwent ligament surgery, without complications 25 days post-trauma. Three of the five non-operated cases underwent the planned ligament treatment, and one patient with a bicruciate knee lesion without collateral ligament involvement underwent ligament surgery without complications at last follow-up.

Discussion

In the present series, vascular lesions, whether symptomatic or not, were systematically associated with true knee dislocation, including three spontaneously or very quickly reduced; this incidence of dislocation is in agreement with the literature [19]. The time to final admission, however, was less than optimal: in four cases, the transfer was more than 24 hours post-trauma; and in three cases, the vascular lesion was operated on after respectively 6, 13 and 26 hours. These intervals are to be seen in the light of the relative amputation risk according to intervention delay, with a threshold of 8 hours according to Green and Allen [8]. Teams receiving patients with bicruciate knee lesion therefore need to set up a management protocol defining the respective roles of emergency teams and orthopedic and vascular surgeons, as has been done for multiple trauma cases [20,21]. Short transfer circuits need drawing up between specialized departments and the emergency departments of institutions that are not able or willing to provide complete care [22].

It is essential for initial clinical examination on admission to include peripheral pulse: this simple examination diagnosed eight of the nine vascular lesions. In case of abnormality persisting after reduction of any dislocation, good practice is clearly codified. In ischemic syndrome, the priority is to revascularize [3,5]. If arteriography is to be performed, doing so in the operating theater saves about 3 hours [23,24]. In non-ischemic pulse abnormality, emergency imaging is mandatory [18]. In the absence of initial abnormality, however, good practice is less well codified. There are many reports of initially normal pulse associated with popliteal artery lesion; incidence ranges from 17 to 55% according to the series [17,25,26], for a mean of 30% [20], although there was only one case out of the 5 in the present series (1.7%). The current dogma advocates systematic late emergency arteriography, given the threat represented by an overlooked vascular lesion [11]. Barnes et al. [27] consider pulse abnormality to be insufficiently sensitive in these cases, with sensitivity of 79% (95% CI: 0.64–0.89), specificity of 91% (95% CI: 0.78–0.96), positive predictive value of 75% (95% CI: 0.61–0.83) and negative predictive value of 93% (95% CI: 0.85–0.96). Gable et al. [15] reach the same conclusion, although suggesting that echo-Doppler might be used. Other authors, however, argue that the absence of abnormality on clinical examination is sufficient to rule out, not an anatomic vascular lesion, but one requiring surgery [5,18,25]. In Stannard et al.’s level-IIa study [25], none of the 116 patients with normal initial examination findings went on to show signs of vascular lesion. Seventeen underwent systematic arteriography which disclosed only one intimal lesion, which could not be treated surgically. They report a positive predictive value of 90% for the clinical examination, a negative predictive value of 100%, sensitivity of 100% and specificity of 99%. These figures are to be compared with those of Hollis et al. [5]: 100% specificity of clinical examination compared to arteriography, 58% specificity, 71% positive predictive value and 100%
negative predictive value, with 82% diagnostic accuracy. In the present series, the sole case of vascular abnormality undetected by clinical examination did not require surgical treatment.

It is, however, to be stressed that Stannard et al.'s [25] surveillance protocol requires surveillance by a nurse every 2 hours for 48 hours and by the admission physician at 4–6 hours, 24 hours and 48 hours postoperatively; such ideal conditions will not always be found in real life.

Ligament lesions are most often managed by surgery. Intraoperative iatrogenic vascular lesions during knee ligament surgery have been described [28], as has intimal lesion decompensation [29]. Such lesions may raise legal questions: was the lesion iatrogenic, or the decompensation of a previously existing lesion? Systematic preoperative imaging thus appears legitimate even when there is no abnormality of pulse.

Although arteriography remains the gold standard for symptomatic vascular lesions [5–25], risk-benefit analysis would not favor it as a systematic attitude. Arteriography is not fully reliable, with 1.2 to 6% false negatives and 2.4 to 7% false positives [30,31]; the false positives can lead to superfluous surgical exploration [25]. Furthermore, there is a rate of associated local or general complications of between 1.7 and 3.3% [25,32].

The ankle-arm index is often advocated in vascular and orthopedic surgery as a diagnostic tool for vascular lesions. It is, however, merely a supplementary screening test and not an imaging technique. There is also disagreement as to the threshold of abnormality, which Hollis, [5] sets at < 0.8 and Abou-Sayed [18] and Mills [33] at < 0.9, the latter giving 95–100% sensitivity and 80–100% specificity in detected vascular lesions requiring surgery. Moreover, it fails to detect infraclinical lesions, is unfeasible in certain cases of multiple trauma (associated shock, presence of harness, associated fracture) and is dependent on the technical conditions of its performance [33]. In the present series, although scheduled to be performed at admission, it was either not assessed or non-contributive. In disagreement with Hollis et al. [5] and Armstrong et al. [20], we do not consider it useful for the orthopedic team managing a bicruciate knee lesion to perform it systematically.

Another possibility, reported by Gable et al. [15], is echo-Doppler, widely used in vascular surgery but little studied in traumatology and in the management of bicruciate lesions of the knee in particular. In a general article on the diagnostic value of echo-Doppler in limb trauma, Bynoe et al. [34] estimate its diagnostic sensitivity at 95%, with 99% specificity and 98% diagnostic accuracy. The small number of patients having had this examination precludes our validating its diagnostic value. Like every ultrasound test, however, its diagnostic accuracy and interpretation are dependent on operator experience; it may not be readily available in emergency; and execution may be hindered by traumatic edema or hematoma [35].

As assessment of bicruciate lesions of the knee generally includes an MRI scan, some authors have advocated angiographic scanning. This examination is accessible in emergency in most centers, and certainly in those managing bicruciate knee trauma. Whole-body scan now forms part of the initial check-up for severe trauma cases [37]. The literature confirms the diagnostic value of multidetector angiography in vascular trauma of the limbs, although to the best of our knowledge no studies have been specifically devoted to vascular lesions in knee trauma [38,39,40]. In the present series, angiography, when performed, induced no errors in the assessment of vascular status.

Conclusion

Assessment of vascular lesions in bicruciate lesions of the knee, with or without dislocation, is initially based on clinical examination and pulse-taking. In case of ischemia, an emergency vascular opinion is sought and generally leads to surgical exploration preceded by in-theater arteriography. In case of non-ischemic pulse abnormality, emergency imaging (arteriography or angiography) is required. In the absence of pulse abnormality, the risk of vascular lesion requiring surgery is slight. If objective imaging is envisaged, and especially when ligament surgery is intended, our preference is for angiography rather than angio-MRI, due to its ease of access and diagnostic accuracy.

Conflicts of interest

None.

References