

Contents lists available at [SciVerse ScienceDirect](http://www.sciencedirect.com)

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Case review

Death due to an unrecognized groin abscess in a drug addict: A retrospective study

Cristian D'Ovidio PhD, MD, Research Fellow*, Paola Vellante MD, Resident in Legal Medicine, Sara Costantini MD, Resident in Legal Medicine, Aldo Carnevale MD, Full Professor

Department of Medicine and Aging Sciences, Section of Legal Medicine, University "G. d'Annunzio" of Chieti-Pescara, Via dei Vestini 31, 66100 Chieti, Italy

ARTICLE INFO

Article history:

Received 28 April 2012

Received in revised form

12 October 2012

Accepted 2 March 2013

Available online xxx

Keywords:

Intravenous drug users

Groin abscess

Femoral vein erosion

ABSTRACT

Intravenous drug injection persists despite health risks and medical complications. Venous thrombosis, septic thrombophlebitis, artery necrosis, arterio-venous fistula, mycotic aneurysm, dissecting hematoma, pseudoaneurysm formation, and soft tissues infections (i.e. abscesses, cellulitis, infected ulcers), are some of the major clinical consequences lives threatening. The aim of this work is to present this unusual autoptoc case of a drug addict man died for an unrecognized groin abscess referred to the Institute of Legal Medicine, University of Chieti, causing femoral vein's erosion, and to analyse the most common patterns of vascular lesions among drug addicts.

It could be stimulated a new scientific debate because groin injections and their vascular complications increase over years; while soft tissue infections may hide vascular lesions' diagnosis. So physicians should have a high index of suspicion for serious vascular problems, among intravenous drug users (IDUs): prevention for avoiding groin injection and a proper treatment are necessary.

© 2013 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.

1. Introduction

The number of intravenous drug users (IDUs) worldwide is estimated to be approximately 13.2 million.¹ Intravenous injection is the most dangerous and one of the favourite drug assumption modality, becoming an important social and health care problem. Morbidity and mortality are related to the effect of substances themselves, and to the risks intrinsic in the practice. In 2008, the European Monitoring Centre on Drugs and Drug Addiction (EMCDDA) had showed that every year, in Europe, there are about 7000–8000 drugs-related deaths. Compared with their contemporaries, individuals abusing illicit drugs suffer a higher risk of premature death for different causes (diseases, accidents, violence, etc.).² Each drug injection carries a risk of vascular lesion. The literature describes many vascular diseases, among IDUs: venous thrombosis,³ septic thrombophlebitis, artery necrosis,⁴ arteriovenous fistula,⁵ mycotic aneurysm, dissecting hematoma and pseudoaneurysm formation.⁶ Physicians should have a high index of suspicion for vascular problems among IDUs, because they often neglect their illnesses and become difficult to treat. An earlier

diagnosis and treatment of these conditions could be possible only with education and awareness of both, patients and physicians.⁷ The aim of this study is to analyse common patterns of vascular injuries among IDUs; and to show you an unusual autoptoc case of death due to an unrecognized groin abscess, which caused a venous lesion and a subsequent hypovolemic shock.

2. Case history

A 43 years old man, drug addict, in treatment with methadone, went to the E.R. of Pescara's hospital, for a right thigh pain. The patient had been dismissed with a simple prescription of a non-steroid ant inflammatory drug (NSAID). The day after, he felt worse, so his relatives have called the Emergency Medical Service. It was diagnosed a right thigh root's abscess. A surgeon consultant confirmed the diagnosis: right thigh root's abscess, partially spontaneously drained. He did not act surgically, according to what documentation describes. In fact, he considered the abscess, already sufficiently drained. At the discharge, he had prescribed antibiotic, anti-inflammatory drugs and a medical check for the day after tomorrow. That day, the patient had skipped the medical check and he dead for severe haemorrhage. The Prosecutor's Office of Pescara deemed necessary an autoptoc study to the Institute of Legal Medicine, University of Chieti - Pescara, Italy.

* Corresponding author. Tel.: +39 0871 3556724, +39 3476987862 (Mobile); fax: +39 0871 3556779.

E-mail addresses: cridov@yahoo.it, c.dovidio@unich.it (C. D'Ovidio).

2.1. Autopsy, histological and toxicological findings

In the right groin of the cadaver, it was found a skin interruption, over the abscess' area. The surrounding site showed: much blood and the outcome of the abscess (Fig. 1). The abscess had involved: the subcutaneous tissue, the surrounding muscles and the vascular bundle. The femoral vein wall showed an area of erosion. (Fig. 2).

The autopsy was completed in every anatomical district, but there were no other death's explications. The microscopic examination of the groin area showed: inflammatory infiltrate of the dermis and epidermal necrosis; skeletal muscle invaded and attacked by an area of suppurative necrosis. The lungs showed signs of pulmonary oedema, with histiocytes filled of brown pigment.

Blood's toxicological analysis showed only a quantity of methadone compatible with therapeutical regimen (0.827 µg/ml). All these findings lead to the diagnosis of death for an irreversible haemorrhagic shock, secondary to the spreading of the groin abscess and subsequent femoral vein's erosion.

3. Discussion

The autopsy highlighted right femoral vein erosion, in the groin abscess' area leading to lethal haemorrhagic shock. To our knowledge, the scientific literature, lacks of a systematic review of deaths due to femoral vessels haemorrhages, among IDUs. Deaths related to these haemorrhages, are mostly associated to lower limbs violent traumas^{8,9} or to medical procedures.^{10,11} There are some case reports of IDUs' death for vascular complications in the international literature, but none of them are referred to be due to venous haemorrhage.¹² The absence of this death cause, gives the opportunity to discuss this case. Parenteral drug injection can cause a wide range of vascular complications, from simple vascular irritation to severe infections, thrombosis and pseudo-aneurysm formation. Injecting drug use via femoral vein puncture has been identified as more widespread than previously recognized and it is associated with considerable morbidity.¹³ Studies¹⁴ have noted shifts towards groin (femoral vein) injection, among UK injectors. A survey¹⁵ of



Fig. 2. Femoral vein wall's erosion (black arrow) with a clot inside (white arrow).

IDUs in multiple locations in England found 45% of 952 IDUs to regularly groin inject, rising up to 58% in some cities. Maliphant et al. had interviewed a total of 92 IDUs and 47 (51%) of these, were currently injecting in their groin.¹⁶ Femoral injections are preferred to peripheral ones for different reasons: difficulty finding other veins, feasibility of the access, lack of visible track marks when clothed.¹⁷ So that lower extremity injecting, accounts for about 50% of the injecting years.¹⁸ Repeated injecting might cause vascular lesions, which affect both veins and arteries, the latter being often the most dramatic. Some Authors have observed two different mechanisms to cause vascular lesions: mechanical trauma and drugs' toxic effect.¹⁹ Vascular lesions usually show this steps-progression: stage I - cicatricial-and-ulcerous lesions formation; stage II – formation of cutaneous-and-vascular fistulas; stage III - development of health-hazardous vascular lesions (i. e., arterial and venous thrombosis, bleedings). The same authors have experimentally confirmed that the main responsible of vascular lesions was the chemical injury: the damaged area infection turned out to be secondary to it.²⁰

4. Venous complications

Common venous complications among IDUs are: deep vein thrombosis (DVT) and chronic venous insufficiency or disease (CVD).⁷ DVT makes the lower limb swollen, erythematous and tender. Investigations should include baseline blood tests and blood cultures if feverish. Usually venography is not possible due to lack of superficial veins, and a Doppler ultrasound should therefore be used to confirm the diagnosis. Contrast enhanced CT is a useful diagnostic test for suspected septic DVT. Treatment should include antibiotics if necessary, anticoagulants with a therapeutic dose of



Fig. 1. Right groin, skin interruption over the abscess' area (arrow).

low molecular weight heparin; while anticoagulation with warfarin can be problematic in IVDUs as they may take substances which interact with the drug and tend to be non-compliant. In cases of a useless conservative medical management, surgical venous thrombectomy, combined with arteriovenous fistula formation (to prevent rethrombosis) has been reported as successful.⁷ Chronic venous insufficiency takes origin from the presence of a deep vein obstruction and subsequent superficial vein regurgitation. It is considered a very common situation among long-term IDUs: in a recent study,²¹ the authors examined walking mobility in relation to CVD for 713 individuals in methadone treatment. CVD was present in 92.3% of participants and it was supported the causal link between leg injection and CVD ($P < 0.01$). Diagnosis is often made after a careful clinical assessment. Diagnostic aids include duplex ultrasonography, venography and plethysmography. Treatment options are limited. Prophylactic measures such, graduated support and advice on leg elevation should be implemented at the first signs of chronic venous insufficiency. Surgery, in the form of venous bypass or perforator ligation has been carried out in IVDUs. Its disappointing results suggest avoiding surgery and preferring a non-operative management in these patients.⁷

5. Arterial complications

After several years of addiction, the peripheral veins, usual route of drug injection, become sclerosed and injection is difficult. Drug addicts may then deliberately or incidentally (missed venous injection) use direct intra-arterial injections. This may generate severe complications especially in the skin and in the underlying structures. Typically, IDUs develop: mycotic arterial pseudoaneurysms mainly in the groin, axilla, and antecubital fossa and/or limb ischemia.

The rate of complications seems to be different according to the drug injected. Some drugs, such as cocaine, acts as a powerful adrenergic agent and may cause a direct local vasoconstriction. The local cytotoxicity of a drug may cause vascular injury (chemical endarteritis). An oral drug suspension, used intravenously, may contain microparticles which act as microemboli.²²

Limb ischemia in IDUs, has been widely reported after intra-arterial injection of a number of substances. The direct toxic effect of the drug produces a chemical endarteritis (i.e. endothelial injury, platelet activation and localized thrombosis). Particulate emboli may, instead, precipitate ischemia through a mechanical occlusion. Ischemia from intra-arterial injection of illicit drugs is common in upper limbs. Lower limbs ischemia may occur as consequence of injection into the femoral artery. The intense pain experience forces IDUs to consult a physician early. Angiography is useful to ascertain the extent of injury, arterial spasm and thrombosis and to determine whether a surgical intervention is necessary. Treatment includes: basic measures such as elevation, physiotherapy, broad-spectrum antibiotics and analgesia. Intravenous heparin should be started immediately. Intravenous iloprost may be considered and intra-arterial vasodilators and steroids may be used once the diagnosis is confirmed. If there is no clinical response, intra-arterial thrombolysis remains a good option. Infusions should be continued for up to 3–4 days as the underlying inflammatory response may continue causing further damage. A second angiography will provide an objective measurement of response. If medical therapies fail, patients commonly require surgical treatment like fasciotomy for compartment syndrome. Ultimately, this event may result in amputation.⁷

In case of IDUs' groin swelling another common arterial complication must be suspected: infected pseudoaneurysms.²³ Intra-arterial or peri-arterial contaminated injections may cause it: the bleeding and subsequent infection of the hematoma causes the vessel's wall breakdown, resulting in pseudoaneurysm.²⁴ The

majority of pseudoaneurysm develops in the femoral artery due to its close proximity to the femoral vein, although upper limb vessels are also at risk.

The prevalence of a mycotic pseudoaneurysm (AMP), among IDUs, is low. A retrospective review estimated the annual prevalence of AMP in this population in 0.03%.²⁵ Of 7795 patient visits, 11 patients had AMP (0.14%). In three cases AMP was not initially suspected; they were treated as having an abscess that has been surgically incised, resulting in arterial rupture. Untreated pseudoaneurysms may progress rapidly and can rupture, causing life-threatening haemorrhage, limb loss, sepsis, and even death. So, a proper management of them is necessary. Given that the swelling can be mistaken for an abscess, duplex ultrasonography should be considered as a first investigation when this diagnosis is in question. Angiography instead, in some cases, has been associated with aneurysm rupture. The treatment is mainly surgical. In fact, the aneurysm should be ligated, excised and the surrounding tissues debrided.²⁶ There is little evidence that infected pseudoaneurysms in IDUs can be treated successfully non-operatively (i.e. supportive management, antibiotics, ultrasound compression). The most controversial aspect of their surgical therapy is whether revascularization is necessary after an aneurysm's excision. In an infected field, a prosthetic graft often leads to occlusion or infection despite the use of an extra-anatomical route. Moreover, autologous vein grafts are often not available in IDUs with sclerosed superficial veins. In addition, even vein grafts carry significant risk of infection and occlusion when used in infected areas. Of the 277 cases reviewed, 199 (72%) were managed by simple ligation and excision. The remaining 78 (28%) cases had either simultaneous or delayed revascularisation. The amputation rate in the non-re-vascularized limbs was 13/199 (6.5%) and 7/78 (9.0%) in those that were revascularized. The number of grafts that became infected or occluded was 21/78 (26.9%).⁷ This recent review demonstrates that simple excision, ligation, debridement and antibiotic therapy should be considered the first line treatment of these lesions; the amputation rates in fact are similar to the revascularized patients.

5.1. Infections and abscesses' prevalence among IDUs

The case described in this article, let focus the attention on deaths related to a severe localized infection causing a venous lesion and subsequent haemorrhage.

Salmon et al.²⁷ consider infections as an injecting-related injury and disease (IRID), differentiating it from injecting-related problems (IRP). Of the 9552 IDUs observed, 26% ($n = 2469$) reported IRP and 10% ($n = 972$) reported IRID. IRP included difficulties finding a vein (18%), prominent scarring or bruising (14%) and swelling of hands or feet (7%). IRID included: abscesses or skin infection (6%), thrombosis (4%), septicaemia (2%) and endocarditis (1%). The most prevalent soft tissue complications, except that scarring, are abscesses and cellulitis, affecting up to 32% of IDUs.²⁷ Skin and soft tissue infections are even the most frequent cause of hospital admission among IDUs.²⁸ In a study²⁹ (a retrospective review of the associated complications of 85 patients with 130 abscesses treated during 108 hospital stays), the majority of abscesses (55%) were located on the lower extremities. In this site the complication rate following injections was significantly higher than in other parts of the body (12/71 vs. 0/55, $P = 0.0005$). Patients with abscesses on the lower extremities had significantly longer hospital stay than those with abscesses on other localizations (8.5 days vs. 4.2 days, $P = 0.0005$) and therefore were more expensive to treat.

Risk factors associated with abscesses production are mainly: way of injection (skin-popping, speedball injection) and poor hygienic conditions.³⁰ The social and physical environments, in which drugs are injected, play a significant role in abscess' development:

frequency and duration of injecting, recent public injecting, needles and/or syringes sharing. These habits favour the contact with a wide range of bacterial, viral, fungal and parasitic pathogens.

Necrotic phenomenon associated with abscesses, can be responsible of lesions to contiguous tissues. If the abscess involves vital area or structures, the situation could become dramatic: in the case observed, there was a femoral venous wall's erosion, with subsequent copious haemorrhage. Usually, abscesses caused by *Clostridia* species, behave in this way.³¹

For all previously said, physicians should pay a special attention in the diagnosis and management of suspected abscesses, even using a radiological guide (i.e. ultrasonography, TC, RMN).³² Abscesses, in fact, may be misdiagnosed for an uncomplicated cellulitis, or may be confused with pseudoaneurysms, hematoma, phlegmon or vein thrombosis. An exploration, excision and debridement of the area, as complete as possible, should be recommended.³³ Primary revascularization is the gold standard in cases of severe groin infections. In case of large vessels involvement, abscess incision alone, without revision of the vascular structures, should be avoided for the possible secondary ruptures.³⁴

6. Conclusion

The case here described confirms data from the international literature: among IDUs vascular lesions are increasing in number, becoming one of the major death causes. Analysing data of some years ago, IDU's deaths in five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) have been mainly associated to fatal poisoning.³⁵ Similar results, have been found, in the same Nordic countries, among young drug addicts (15–34 years).³⁶ In 2007, the same study was repeated, in comparison with previous data of 2002, 1997 and 1991: fatal poisoning has been still indicated as the main death cause.³⁷ Some other analyses have confirmed accidental poisoning as the major death cause (64.3%)³⁸ and have considered natural causes as just a minority (22%).³⁹

To our knowledge, literature lacks of comprehensive data about mortality rate connected to venous haemorrhages, among IDUs. Therefore it is difficult to express any considerations on this subject. What is possible to do is to stimulate the scientific debate hoping to collect more data, because drug assumption modality is changing and vascular complications seem to increase, exactly for this reason. For example, crack-based speedball injection is a new drug assumption modality that IDUs are usual to link with the shifts towards groin injection. They consider it as an acceptable risk and not merely as a last resort.¹⁵ So groin injection persists, despite an awareness of health risks and medical complications. Only prevention in drug addiction programs and a major awareness among physicians could reduce complications and costs related to drug use on the lower limbs.

Ethical approval
None.

Funding
None.

Conflict of interest
The authors declare no conflict of interest.

References

1. Aceijas C, Stimson GV, Hickman M, Rhodes T United Nation Reference Group on HIV/AIDS Prevention and care among IDU in Developing and Transitional Countries. Global overview of injecting drug use and HIV infection among injecting drug users. *AIDS* 2004 Nov 19;18(17):2295–303.

2. EMCDDA. 2008 annual report: the state of drugs problem in Europe June 2008. Lisbon.
3. McColl MD, Tait RC, Greer IA, Walker ID injecting drug use is a risk factor for deep vein thrombosis in women in Glasgow. *Br J Haematol* 2011 Mar;112(3):641–3.
4. Mullan MJ, Magowan H, Weir CD. Femoral artery necrosis due to parenteral intravascular drug misuse: a case report and a literature review. *Ulster Med J* 2008 Sep;77(3):203–4.
5. Roszler MH, McCarroll KA, Donovan KR, Rashid T, Kling GA. The groin hit: complications of intravenous drug abuse. *Radiographics* 1989;9(3):487–508.
6. Kozelj M, Kobilica N, Flis V. Infected femoral pseudoaneurysms from intravenous drug abuse in young adult. *Wien Klin Wochenschr* 2006;118(Suppl. 2):71–5.
7. Fiddes R, Khattab M, Abu Dakka M, Al-Khaffaf H. Patterns and management of vascular injuries in intravenous drug users: a literature review. *Surgeon* 2010;8:353–61.
8. Kauvar DS, Sarfati MR, Kraiss LW. National trauma databank analysis of mortality and limb loss in isolated lower extremity vascular trauma. *J Vasc Surg* 2011 Jun;53(6):1598–603.
9. Cooke R, Fitzpatrick J. Haemorrhage from femoral vein cannula: an additional potential source of haemorrhage among intravenous drug users. *Emerg Med J* 2009;26:675.
10. Zhou C, Langlois NE, Byard RW. Femoral artery pseudoaneurysm and sudden death. *J Forensic Sci* 2012 Jan;57(1):254–6.
11. Romaguera R, Wakabayashi K, Laynez-Carnicero A, Sardi G, Maluenda G, Bendor I, et al. Association between bleeding severity and long-term mortality in patients experiencing vascular complications after percutaneous coronary intervention. *Am J Cardiol* 2012 Jan 1;109(1):75–81.
12. Türk EE, Lockemann U, Tsokos M. Fatal bleeding from major femoral vessels: three case reports. *Int J Leg Med* 2007;121:220–2.
13. Senbajo R, Strang J. The needle and the damage done: clinical and behavioural markers of severe femoral vein damage among groin injectors. *Drug Alcohol Depend* 2011;119:161–5.
14. Rhodes T, Stoneman A, Hope V, Hunt N, Judd A. Groin injecting in the context of crack cocaine and homelessness: from 'risk boundary' to 'acceptable risk'? *Int J Drug Policy* 2006;17:164–70.
15. Rhodes T, Briggs D, Kimber J, Jones S, Holloway G. Crack – heroin speedball injection and its implications for vein care: qualitative study. *Addiction* 2007;102:1782–90.
16. Maliphant J, Scott J. Use of the femoral vein ('groin injecting') by a sample of needle exchange clients in Bristol, UK. *Harm Reduction J* 2005;2:6.
17. Coffin PO, Coffin LS, Murphy S, Jenkins LM, Golden MR. Prevalence and characteristics of femoral injection among Seattle-Area Injection Drug Users. *J Urban Health* 2012;89(2):365–72.
18. Pieper B, Templin T. Chronic venous insufficiency in person with an history of injection drug use. *Res Nurs Health* 2001;24(5):423–32.
19. Ducrey N, Calanca L, Hayoz D. Drug addicts as cardiovascular patients. *Rev Med Suisse* 2006 Feb 1;2(51):337–8. 340–1.
20. Sultanaliev TA, Tursynbaev SE, Ivakin VM. Aetiology and pathogenesis of damages to blood vessels in drug addicts. *Angiol Sosud Khir* 2007;13(2):25–33.
21. Pieper B, Templin TN, Kirsner RS, Birk TJ. Injection-related venous disease and walking mobility. *J Addict Dis* 2010 Oct;29(4):481–92.
22. Del Giudice P, Vandenbos F, Boissy C, Cua E, Marion B, Bernard E, et al. Cutaneous complications of direct intra-arterial injections in drug addicts. *Acta Derm Venereol* January 19, 2005;85.
23. Coughlin PA, Mavor AL. Arterial consequences of Recreational drug use. *Eur J Vasc Endovasc Surg* 2006;32:389–96.
24. Naqi SA, Khan HM, Akhtar S, Shah TA. Femoral pseudoaneurysm in drug addicts – excision without revascularization is a viable option. *Eur J Vasc Endovasc Surg* 2006;31:585–7.
25. Tsao JW, Marder SR, Goldstone J, Bloom AL. Presentation, diagnosis, and management of arterial mycotic pseudoaneurysms in injection drug users. *Ann Vasc Surg* 2002 Sep;16(5):652–62.
26. Lupattelli T, Garaci FG, Basile A, Minnella DP, Casini A, Clerissi J. Emergency stent grafting after unsuccessful surgical repair of a mycotic common femoral artery pseudoaneurysm in a drug abuser. *Cardiovasc Intervent Radiol* 2009;32:347–51.
27. Salmon AM, Dwyer R, Jauncey M, van Beek I, Topp L, Maher L. Injecting-related injury and disease among clients of a supervised injecting facility. *Drug Alcohol Depend* 2009 Apr 1;101(1–2):132–6.
28. Takahashi TA, Merrill JO, Boyko EJ, Bradley KA. Type and location of injection drug use-related soft tissue infections predict hospitalization in Journal of Urban Health. *Bull New York Acad Med* March 2003;80(1).
29. Pfefferkorn U, Viehl CT, Bassetti S, Wolff T, Oertli D. Injection site abscesses in intravenous drug users. Frequency of associated complications related to localisation. *Chirurg* 2005 Nov;76(11):1053–7.
30. Murphy EL, DeVita D, Liu H, Vittinghoff E, Leung P, Ciccarone DH, et al. Risk factors for skin and soft-tissue abscesses among injection drug users: a case-control study in CID. 2001 July 1;33(1):35–40.
31. Ebright JR, Pieper B. Skin and soft tissue infections in injection drug users. *Infect Dis Clin North Am* 2002 Sep;16(3):697–712.
32. Schulz S, Beckenbach C, Philipp M, Hengstmann J. Color coded duplex sonography of inguinal vessels in i.v. *Drug Addicts Vasa* 2002 Feb;31(1):7–13.
33. Khalil PN, Huber-Wagner S, Altheim S, Bürklein D, Siebeck M, Hallfeldt K, et al. Diagnostic and treatment options for skin and soft tissue abscesses in injecting drug users with consideration of the natural history and concomitant risk factors. *Eur J Med Res* 2008 Sep 22;13(9):415–24.

34. Scheuerlein H, Ruff S, Haage P, Zirngibl H, Fraunhofer S, Settmacher U. Groin abscesses and vascular catastrophes in intravenous drug users, strategy and results. *Zentralbl Chir* 2008 Feb; **133**(1):55–60.
35. Steentoft Aa, Teige Bb, Holmgren Pc, Vuori Ed, Kristinsson Je, Kaa Ef, et al. Drug addict deaths in the Nordic countries: a study based on medicolegally examined cases in the five Nordic countries in 1991. *Forensic Sci Int* January 12, 1996:109–18.
36. Steentoft Aa, Teige Bb, Holmgren Pc, Vuori Ed, Kristinsson Je, Kaa Ef, et al. Fatal poisonings in young drug addicts in the Nordic countries: a comparison between 1984–1985 and 1991. *Forensic Sci Int* March 5, 1996:29–37.
37. Simonsen KW, Normann PT, Ceder G, Vuori E, Thordardottir S, Thelander G, et al. Fatal poisoning in drug addicts in the Nordic countries in 2007. *Forensic Sci Int* 2011 15; **207**(1–3):170–6.
38. Oyefeso A, Ghodse H, Clancy C, Corkery J, Goldfinch R. Drug abuse-related mortality: a study of teenage addicts over a 20-year period. *Soc Psychiatry Psychiatr Epidemiol* 1999 Aug; **34**(8):437–41.
39. Jönsson AK, Holmgren P, Druid H, Ahlner J. Cause of death and drug use pattern in deceased drug addicts in Sweden, 2002–2003. *Forensic Sci Int* 2007 Jul 4; **169**(2–3):101–7.