Hand Surgery and Rehabilitation 38 (2019) 87–90

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

Original article

Designing a minimally-invasive, ultrasound-guided, percutaneous flexor tendon sheath lavage technique: a cadaver study

Mise au point d'une technique mini-invasive échoguidée de lavage percutané de la gaine des fléchisseurs des doigts: étude anatomique

E. Boyer [1], Y. Igeta [1,2], S. Jiang [3,4], M. Arianni [5], F. Goldammer [1], G. Prunières [1], A. Paun [1], P. Vernet [1], P. Liverneaux [1,*]

[1] *Department of Hand Surgery, SOS main, CCOM, University Hospital of Strasbourg, FMTS, University of Strasbourg, Icube CNRS 7357, 10 avenue Baumann, 67400 Illkirch, France*
[2] *Department of Orthopedic Surgery, Juntendo Nerima Hospital, 3-1-10, Takanedai, Nerima-ku, Tokyo, 177-8521, Japan*
[3] *Department of Hand Surgery, Huashan Hospital, Shanghai Medical College, Fudan University, 138 Yixueyuan Road, Shanghai, 200040, China*
[4] *Department of Hand and Upper Extremity Surgery, Jing'an District Central Hospital, No.12 Wulumuqi Middle Road, 200040, Shanghai, Popular Republic of China*
[5] *Hand Clinic, Ramsay Premier Bintaro Hospital, Jl. MH Thamrin no.1, Bintaro Jaya sector Tangerang Selatan, 15224, Banten, Indonesia*

ARTICLE INFO

Article history:
Received 23 July 2018
Received in revised form 25 September 2018
Accepted 14 December 2018
Available online 14 January 2019

Keywords:
Minimally invasive
Percutaneous washout
Flexor tendon sheath

ABSTRACT

The goal of this study was to develop a minimally-invasive, ultrasound-guided percutaneous flexor tendon sheath lavage technique on cadaver model. Two catheters were inserted using ultrasound guidance at the proximal and distal ends of the tendon sheath in 20 fingers from cadaveric forearms. Percutaneous injection of a saline solution colored with methylene blue resulted in anterograde lavage of the flexor tendon sheath.

The technique was successful in 13 out of 20 cases. The proximal catheter was in the correct position in 17 cases and the distal catheter was correctly positioned in 15 cases. The flexor tendons were continuous in all cases and had puncture wounds in 9 cases.

Based on our study, this minimally-invasive, ultrasound-guided percutaneous lavage of the flexor tendon sheath was effective in 65% of cases and safe in 100% of cases in the index, middle and ring fingers. If this percutaneous lavage fails, it is always possible to switch to a conventional open technique.

Mots clés :
Mini-invasif
Lavage percutané
Gaine des fléchisseurs des doigts

RÉSUMÉ

Le but de ce travail était de mettre au point une technique mini-invasive échoguidée de lavage percutané de la gaine des tendons fléchisseurs des doigts sur un modèle anatomique.

Deux cathéters étaient insérés sous guidage échographique à chacune des extrémités proximale et distale de la gaine tendineuse des 20 doigts médians de 7 avant-bras de cadavres. Une injection percutanée de sérum physiologique au bleu de méthylène par le cathéter proximal permettait le lavage antérograde de la gaine des tendons fléchisseurs.

La technique était réussie dans 13 cas sur 20. Le cathéter proximal était bien positionné dans 17 cas et le distal dans 15 cas. L'appareil fléchisseur était continu dans tous les cas, avec des lésions punctiformes dans 9 cas.

Nos résultats ont montré que cette technique mini-invasive échoguidée de lavage percutané de la gaine des fléchisseurs des doigts sur un modèle anatomique était efficace à 65% et sans risque dans 100% des cas sur l'index, le majeur et l'annulaire. En cas d'échec de la technique, il est toujours possible de convertir par une technique ouverte conventionnelle.

* Corresponding author: Department of Hand Surgery, University Hospital of Strasbourg, 10 avenue Baumann, 67403 Illkirch F-cedex, France
E-mail address: Philippe.liverneaux@chru-strasbourg.fr (P. Liverneaux).

https://doi.org/10.1016/j.hansur.2018.12.001
2468-1229/

Introduction

Infections of the hand are a common reason for consultation but can be difficult to diagnose [1]. Among these infections, pyogenic flexor tenosynovitis is an emergency because any diagnostic or treatment delay will impact the functional outcome [2]. The prognosis is related to the severity based on the intraoperative appearance of the sheath and flexor tendons [3]. Stiffness is one of the main aftereffects, especially when extensive surgical approaches are used [4]. For this reason, some authors have developed closed tendon sheath lavage techniques using a catheter [5]. However, no minimally invasive technique has been published in the literature.

The goal of this study was to develop a minimally invasive, ultrasound-guided, percutaneous flexor tendon sheath lavage technique on a cadaver model. The primary hypothesis was that the success rate of the technique would be greater than 50%. The secondary hypothesis was that the integrity of the flexor tendons would be maintained in all cases when the technique was performed.

Material and methods

Our material included seven fresh cadaveric forearms free from any scars, three level-2 hand surgeons [6] experienced in diagnostic ultrasound imaging, one ultrasound scanner (LOGIQ E R7®, General Electric™, Fairfield, CT, USA) equipped with a L8-18i probe (8-18 MHz), ultrasound gel (Uni'gel US®, Asept Inmed™, Quint Fonsegrive, France), 40 catheters size 14 gauge (BD Insyte®, Becton Dickinson™, Sandy, UT, USA), saline solution colored with methylene blue, and three non-Luer lock syringes (BD Discardit™ II, Becton Dickinson™, Sandy, UT, USA).

The technique was performed on the central fingers: index, middle and ring fingers. The thumb and little finger were not used because these tendon sheaths sometimes communicate with other fingers. Two catheters were inserted using ultrasound guidance at the proximal (Video 1) and distal (Video 2) ends of the tendon sheaths. Percutaneous injection of saline solution colored with methylene blue resulted in anterograde lavage of the tendon sheath (Fig. 1).

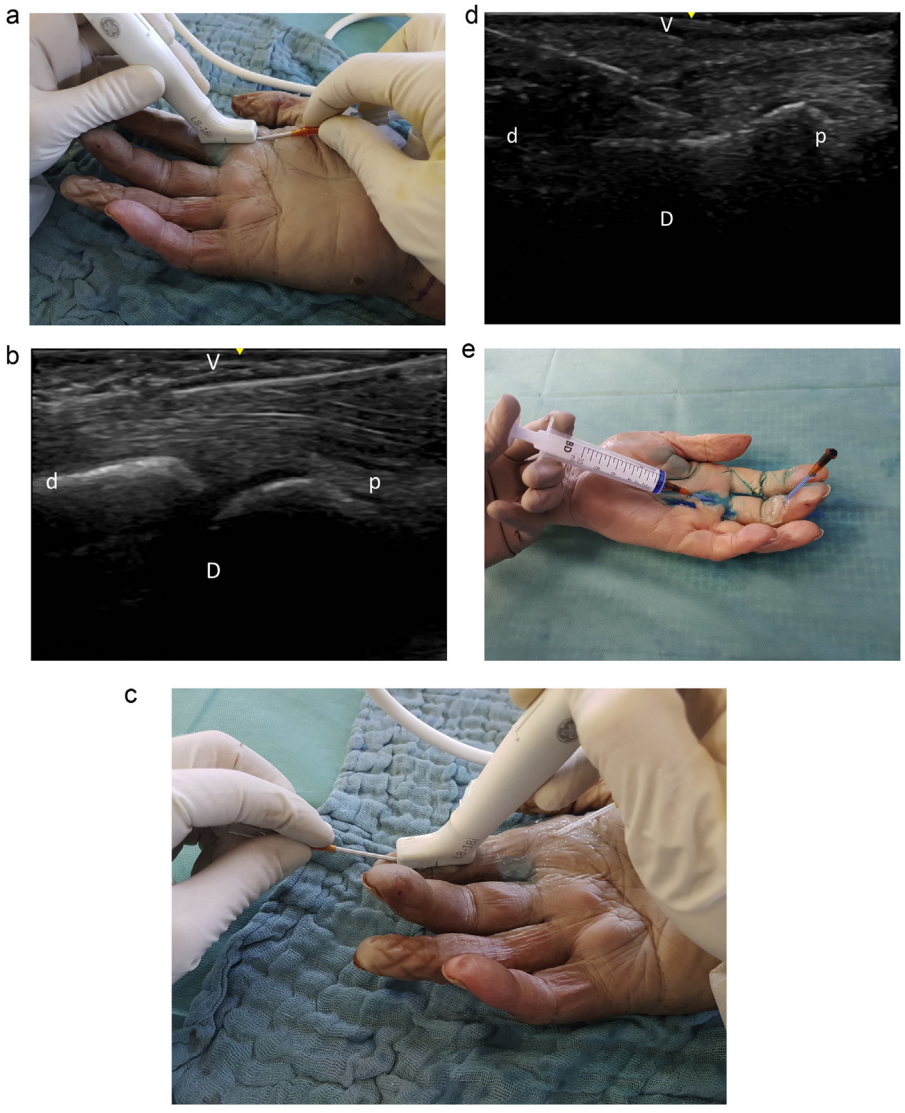

Fig. 1. Minimally invasive technique for flexor tendon sheath lavage. Ultrasound-guided introduction of the proximal catheter (A). Ultrasound view of the introduction of the proximal catheter (B). Ultrasound-guided introduction of the distal catheter (C). Ultrasound view of the introduction of the distal catheter (D). Methylene-blue colored saline solution exiting the distal catheter. V: volar; D: dorsal; P: proximal; D: distal

Table 1
Results of a minimally-invasive percutaneous washout technique of the flexor tendon sheath on 20 fingers of anatomical models

Specimen	Digit	Success	Assessment			
			Catheter inside the tendon sheath		Anatomy of the flexor tendons	
			proximal catheter	distal catheter	Uninterrupted	Intact
(A)	(N)	(Y/N)	(Y/N)	(Y/N)	(Y/N)	(Y/N)
A	2	Y	Y	Y	Y	Y
	3	Y	Y	Y	Y	Nd
	4	Y	Y	Y	Y	Np
B	2	N	Y	N**	Y	Np + Nd
	3	N	N*	Y	Y	Y
	4	Y	Y	Y	Y	Np
C	2	Y	Y	N**	Y	Nd
	3	Y	Y	N*	Y	Nd
	4	N	N**	Y	Y	Np
D	2	Y	Y	Y	Y	Nd
	3	Y	Y	Y	Y	Y
	4	Y	Y	Y	Y	Y
E	2	Y	Y	Y	Y	Y
	3	Y	Y	Y	Y	Y
	4	N	Y	N*	Y	Y
F	2	N	N*	Y	Y	N
	3	N	Y	Y	Y	Y
	4	Y	Y	Y	Y	Y
G	2	N	Y	N**	Y	Nd
	3	Y	Y	N**	Y	N

Y: yes; *N*: no. *N**: catheter outside the tendon sheath; *N***: catheter inside the tendon sheath and inside the tendon; *Np*: puncture wound due to the insertion of the proximal catheter; *Nd*: puncture wound due to the insertion of the distal catheter.

The evaluation consisted in assessing the success rate of the technique, verifying after incision of the skin if the catheter was in the right place, and looking for signs of tendon damage. If the blue saline solution flowed through the distal catheter, the technique was considered as a success (Video 3); if not, it was considered a failure (Videos 4 and 5). If the catheter was placed inside the tendon sheath, its position was considered as a success; if not, it was considered a failure. The position of the catheters was checked at both the proximal and distal ends. If the flexor tendons did not show signs of rupture due to the insertion of the catheter they were rated as continuous, if not they were rated as ruptured. If the tendons did not show signs of lesion due to the insertion of the catheters they were rated as intact, if not they were rated as injured. The site of the lesion was noted as proximal, distal or both.

Results

The analytical results are presented in Table 1. This minimally invasive technique was a success in 13 of 20 cases. The proximal catheter was positioned correctly in the tendon sheath in 17 of 20 cases. The distal catheter was positioned correctly in 15 of 20 cases. The tendons were continuous in all cases and intact in 9 of 20 cases. The tendons were injured on the proximal end in three cases and on the distal end in eight cases. The lesions were puncture wounds in all cases. In two cases, the syringe disengaged from the proximal catheter due to fluid pressure. We did not observe any fluid diffusion into subcutaneous tissues during cadaver dissection.

Discussion

It is commonly acknowledged that the diagnosis of pyogenic flexor tenosynovitis is clinical [7,8]. Recently, some authors have shown the relevance of ultrasound imaging in the diagnosis of difficult cases. A unilateral 20% increase in the tendon sheath's diameter at the A2 pulley indicates the need for surgical lavage [9]. In the majority of cases, open surgical treatment is indicated [10]. Some authors recommend using a minimally invasive technique to drain the tendon sheath by inserting a catheter after a proximal approach to the A1 pulley [5,11]. Others suggest using ultrasound for the diagnosis of pyogenic flexor tenosynovitis [12]. The goal of this study was to develop a minimally-invasive, ultrasound-guided technique for percutaneous lavage of the flexor tendon sheath.

One of the weaknesses of our study is that the flexor tendons of the thumb and little finger were not tested it is difficult to locate their tendon sheath in the wrist compared to the tendon sheath of the three central fingers at the distal palmar crease. The success rate of our minimally invasive technique was considerably inferior to 100%. This low rate can be explained by several factors. The three level-2 surgeons [6] had experience with ultrasound imaging but had never performed this technique before. It is likely that more experienced surgeons with existing knowledge of the technique would have a greater success rate. Regardless of the success rate, our technique can always be converted to a conventional open technique. The causes of failure were linked to mistakes in the positioning of the proximal catheter (three cases) or the distal catheter (six cases). The catheter was outside the tendon sheath in four cases and inside the tendon in five cases. The failure rate of distal catheter positioning was twice as high as proximal catheter positioning because of the anatomy of the tendon sheath as it narrows from the proximal to the distal end of the fingers. The precise positioning of the catheter under ultrasound guidance is more difficult in a tight space. The success rate of correct catheter positioning would likely improve once surgeons gain experience with this technique. Among the strengths of our study are that there were no flexor tendon ruptures. Only puncture wounds were found at the proximal end in three cases and the distal end of the tendons in eight cases. The technique can therefore be considered safe.

In two cases, the syringe disengaged from the catheter because of fluid pressure. It is important to use non-Luer lock syringes in order to avoid pressure injection of the lavage solution.

In a clinical scenario, the fluid in the tendon sheath can be collected to check its appearance and perform a microbiological evaluation. Here, no fluid was present in the cadavers.

Our study's primary hypothesis was verified as the success rate of our minimally invasive technique was greater than 50%. The secondary hypothesis was verified as the continuity of the flexor tendons was preserved in all cases.

Conclusion

Our results have shown that this minimally invasive, ultrasound-guided, percutaneous flexor tendon sheath lavage technique was effective in 65% of cases and safe in 100% of cases. If the lavage fails, it is always possible to convert to a conventional open technique. This technique still needs to be verified in a clinical study.

Other authors:
Etienne Boyer
Yuka Igeta
Su Jiang, M.D.
Margareta Arianni
Fiona Goldammer
Guillaume Prunières
Alexandru Paun
Paul Vernet

Conflicts of Interest

Philippe Liverneaux has conflicts of interest with Newclip Technics, Argomedical, Zimmer Biomet, Biomodex.
The other authors declare that they have no competing interest.

Acknowledgement

EWAS (European Wrist Arthroscopy Society) which provided cadavers

IRCAD (Institut de Recherche sur les Cancer de l'Appareil Digestif) which provided the training center

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.hansur.2018.12.001.

References

[1] Houshian S, Seyedipour S, Wedderkopp N. Epidemiology of bacterial hand infections. Int J Infect Dis 2006;10:315–9.
[2] Pang HN, Teoh LC, Yam AK, Lee JY, Puhaindran ME, Tan AB. Factors affecting the prognosis of pyogenic flexor tenosynovitis. J Bone Joint Surg Am 2007;89:1742–1748.
[3] Michon J. Phlegmon of the tendon sheaths. Ann Chir 1974;28:277–80.
[4] Sokolow C, Dabos N, Lemerle JP, Vilain R. Bacterial flexor tenosynovitis in the hand. A series of 68 cases. Ann Chir Main 1987;6:181–8.
[5] Neviaser RJ. Closed tendon sheath irrigation for pyogenic flexor tenosynovitis. J Hand Surg Am 1978;3:462–6.
[6] Tang JB, Giddins G. Why and how to report surgeons' levels of expertise. J Hand Surg Eur 2016;41:365–6.
[7] Kanavel AB. Infections of the hand: a guide to the surgical treatment of acute and chronic suppurative processes of the fingers, hand, and forearm. Lea and Febiger, Philadelphia, 1912.
[8] Henry M. Septic flexor tenosynovitis. J Hand Surg Am 2011;36:322–3.
[9] Prunières G, Igeta Y, Hidalgo Díaz JJ, Gouzou S, Facca S, Xavier F, Liverneaux P. Ultrasound for diagnosis of pyogenic flexor tenosynovitis. Hand Surg Rehab 2018 May 11.
[10] Stevanovic MV, Sharpe F. Acute Infections. In: Green DP (ed). Operative hand surgery - 6th ed. Vol 1. Philadelphia: Elsevier, 2011:41-84.
[11] Gutowski KA, Ochoa O, Adams WP Jr. Closed-catheter irrigation is as effective as open drainage for treatment of pyogenic flexor tenosynovitis. Ann Plast Surg 2002;49:350-4.
[12] Jardin E, Delord M, Aubry S, Loisel F, Obert L. Usefulness of ultrasound for the diagnosis of pyogenic flexor tenosynovitis: A prospective single-center study of 57 cases. Hand Surg Rehabil 2018;37:95–8.