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## Ultrasound assessment of the morphology of iatrogenic pseudoaneurysms as a prognostic factor in compression therapy

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### Summary

**Background:**

Limiting inconvenience of compression therapy of iatrogenic pseudoaneurysm (IPA) seems to be a good reason to establish additional criteria for assessment of the probability of achieving embolization of a pseudoaneurysm after conventional treatment. As a result, patients who currently are qualified for ineffective compression therapy could be originally selected for operative treatment.

**Material/Methods:**

The study group comprised 155 patients with pseudoaneurysms resulting from catheterization of the femoral artery. In all cases, IPA morphology was assessed in duplex Doppler ultrasound and its elements linked with the efficacy of compression therapy.

**Results:**

The following parameters of IPA morphology result in significantly worse prognosis for successful conservative treatment with compression: diameter (> 30 mm), cavity volume (> 30 cm<sup>3</sup>), IPA's multiloculation, lack of progression in thrombosis of IPA cavity, the neck arising from the external iliac artery or the profunda femoris artery as well as from the posterior or lateral wall of any artery.

**Conclusions:**

Skipping compression therapy and favoring primary operative treatment should be considered in all these cases. In this way, the number of patients who undergo unsuccessful conservative treatment in a course of several days will be significantly reduced, contributing to a decrease in costs of the therapy and minimizing inconvenience experienced by patients.

**Key words:**

endovascular procedures • complications • pseudoaneurysm • conservative therapy • duplex Doppler ultrasound

**PDF file:**

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### Background

Iatrogenic pseudoaneurysms are the most frequent complication of endovascular procedures (0.02-9%), requiring specific conservative or operative treatment [1, 2, 3, 4]. Only 30-58% of cases are expected to resolve with spontaneous thrombosis [5, 6]. Among numerous treatment options, originally compression therapy is used, resulting in embolization of 20-100% of pseudoaneurysms [7, 8, 9]. Apart from varied efficacy and possible contraindications to compression

therapy, this method causes a great deal of inconvenience to patients. Prolonged, forced and painful compression, immobilization in bed, necrotic changes in the skin or paresthesias lasting even several months after treatment cessation [10].

To limit inconvenience attributed to IPA therapy, it seems reasonable to establish additional criteria for assessment of the probability of embolization after conservative treatment. As a result, patients who are currently qualified for

ineffective compression therapy could be originally selected for thrombin injection or surgical treatment. We have observed so far that the morphology of iatrogenic pseudoaneurysms assessed in duplex Doppler ultrasound could be such an additional criterion. The purpose of our study was to analyze usefulness of the IPA morphology assessment in qualification of patients for conservative or operative treatment respectively.

## Materials and methods

A group of 155 patients who developed femoral artery pseudoaneurysm after endovascular procedures was evaluated (91 patients had undergone coronarography or peripheral angiography and coronary or peripheral angioplasty had been performed in 64 cases). Patients were treated in three different centers where endovascular procedures are performed. The study group comprised 83 males and 72 females ranging in age from 36 to 65 years (average 58.3). Patients with conditions that could significantly worsen the result of compression therapy (BMI > 30, substantial abdominal obesity, signs of fascial tightness in the thigh or necrotic changes of the groin skin) were excluded from the study [4, 15].

At the moment of endovascular procedure, 149 patients were receiving one or two of the following antiplatelet agents: acetylsalicylic acid < 100 mg/day or ticlopidine 2x250 mg/day. All the patients that underwent angioplasty were given 5000 units of unfractionated heparin during the procedure. Treatment dose of low molecular weight heparin was administered on the following 1-4 days with concurrent administration of two antiplatelet drugs.

Femoral artery puncture was performed with local anesthesia. Introducers of 6-7F size were used during diagnostic procedures while operative procedures required 7-9F size. In most patients, introducers were removed right after the procedure. In 13 cases, the removal took place within 12 hours after completion of the procedure. The hand compression lasting 10 to 15 minutes was applied every time after the removal of catheters, then bandage compression was fixed for 6 hours.

In all patients enrolled into the study, the presence of pseudoaneurysm was confirmed within 6 to 48 hours after femoral artery catheterization. The diagnosis was established on the basis of duplex Doppler ultrasound performed with Siemens Sonoline Elegra apparatus with linear (5 - 9 MHz) and/or convex (3 - 3.5 MHz) transducers. The follow-

ing elements of IPA morphology were assessed during the examination: diameter in cross-section, volume of the cavity and possible presence of a thrombus, length and diameter of the neck, blood flow velocity inside the connecting canal; coexistence of arteriovenous fistulas and placement of the IPA entry in the specific segment of feeding artery.

After the presence of a pseudoaneurysm had been confirmed in diagnostic imaging, compression therapy in one of two forms was commenced. Due to considerable uniformity of presented clinical symptoms, the qualification to specific treatment modalities was random and greatly depended on the experience of the institution where the treatment took place. Two groups of patients were specified:

- 61 patients (group 1) treated with tightly rolled pressure dressing (50x50x100 mm). The pressure was exerted by bandaging the groin area with an elastic band. Control examination in duplex Doppler was performed after 24 hours. In case of the unsuccessful result, compression therapy was continued during the next 24 hours.
- 94 patients (group 2) treated with directed hand compression. After the location had been established and marked in ultrasound examination, hand compression was applied and continued for 20-40 minutes with 5 minute breaks after every 10 minutes of compression. The entire session was repeated if the result was bad.

Due to unsatisfying results achieved with ultrasound-guided compression with transducer we resigned from instituting this treatment option. The efficacy was assessed in duplex Doppler ultrasound examination. Complete embolization of the pseudoaneurysm was regarded as a successful treatment outcome. There were the following bad prognostic factors and conditions disqualifying from further use of compression therapy: lack of enlargement of the thrombus in IPA cavity, gradual enlargement of the cavity, symptoms of lower limb ischemia or shock, abrasion or necrotic changes of groin skin. Lack of progress in conservative treatment or occurrence of undesirable symptoms were indications for surgery. The statistical calculations were performed using Statistica software.

## Results

The frequencies of IPA entry in specific segments of the femoral artery are shown in table 1. The differences between two groups are statistically insignificant.

**Table 1.** Arterial puncture site in specific segments of arteries in groin.

Group (number of patients diagnosed with pseudoaneurysm)	Arterial puncture site			
	EIA	CFA	Arteries below CFA bifurcation	
			SFA	PFA
Group 1 (n=61)	7.6%	54.3%	38.1%	
			10.2%	27.9%
Group 2 (n=94)	8.2%	48.4%	43.4%	
			13.9%	29.5%

**Table 2.** The elements of assessment of iatrogenic pseudoaneurysm morphology related to the efficiency of compression therapy.

Parameters of pseudoaneurysm morphology		IPAs treated successfully	IPAs treated unsuccessfully	Statistical significance
cavity	diameter	2.8±1.4 cm	3.6±1.7 cm	p<0.05
	volume	11.3±6.1 cm <sup>3</sup>	26.2±15.8 cm <sup>3</sup>	p<0.05
	volume of thrombi	38±22%	15±13%	si
canal	length	1.13±0.86 cm	0.67±0.49 cm	si
	diameter	0.04±0.02 cm	0.07±0.04 cm	si
	blood flow velocity	82±24 cm/s	74±36 cm/s	si
coexistence of arteriovenous fistula		1 patient	6 patients	p<0.05
multiloculated pseudoaneurysm		1 patient	7 patients	p<0.05
location relative to fascia	suprafascial	9 patients	none	p<0.05
	intrafascial	101 patients	45 patients	p<0.05

si – statistically insignificant

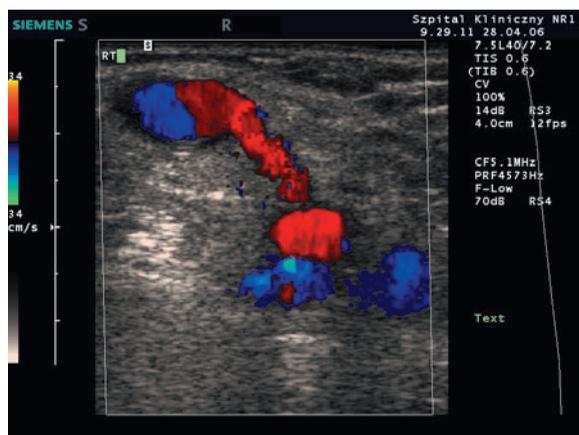
We observed successful result of treatment, that is complete embolization of the pseudoaneurysm, in 63.9% of patients treated with a pressure dressing and 75.5% of patients in whom directed hand pressure was applied. The difference in the efficacy of respective treatment options was statistically insignificant.

Average values +/- standard deviation of assessed IPA morphology elements with the final result taken into account are presented in Table 2.

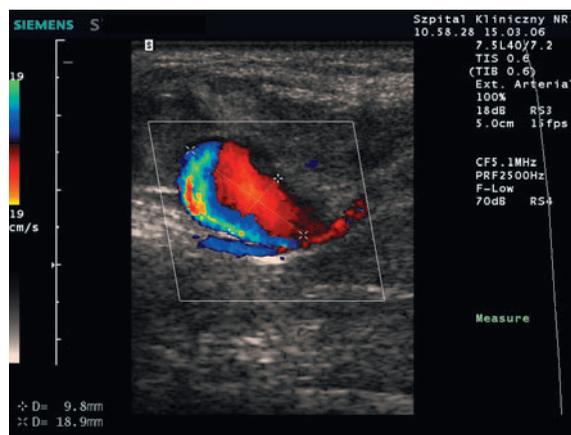
Successfully treated pseudoaneurysms were significantly smaller compared to those that resisted embolization, which resulted in smaller both cross-sectional diameter and volume of cavities. At the same time, in cured IPAs there were more often some thrombi that filled greater part of the cavities – the difference was statistically insignificant. Subsequent follow-up examinations showed that more important than the absolute size of thrombi at the beginning of the treatment was the progression of their size. Gradual enlargement of a thrombus is an important prognostic factor for achieving complete embolization. The efficiency of therapy was greater when the IPA cavities were supplied by long, thin, tortuous canals (fig. 1). The results were worse in case of pseudoaneurysms with

short canals, being adjacent to the walls of injured vessels (fig. 2). Blood flow velocity was greater in canals of pseudoaneurysms which resolved successfully with compression therapy. All the differences between two groups related to the parameters of the morphology of canals were insignificant.

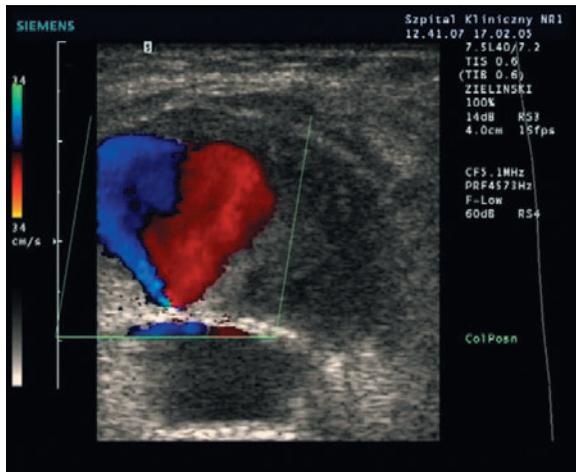
The suprafascial location of cavities was definitely more favorable – the success rate of 100% was achieved in this case. IPAs located infrafasially were associated with a lower success rate – 42% (p<0.05). We obtained meaningfully unfavorable results with the treatment of multiloculated IPAs (fig. 3a, 3b). Only 1 (14.3%), having two cavities, of 8 such pseudoaneurysms resolved with thrombosis. In 7 other cases embolization occurred only in more superficially localized cavities. The results were significantly worse than those obtained in treatment of single-cavity IPAs (success rate of 73.6%) (p < 0.05). Only in 1 of 7 pseudoaneurysms with concomitant arteriovenous fistulas successful resolution with thrombosis was observed. In 6 other cases, we did not notice even a significant increase in the size of thrombi (p < 0.01). The efficiency of treatment was significantly dependent on the localization of the IPA entry into specific segments of vessels in the groin. Trauma to the common femoral artery (CFA) or the superficial femoral



**Figure 1.** Pseudoaneurysm arising from the anterior wall of the common femoral artery, supplied by a long canal.



**Figure 2.** Pseudoaneurysm with a wide entry and no connecting canal.

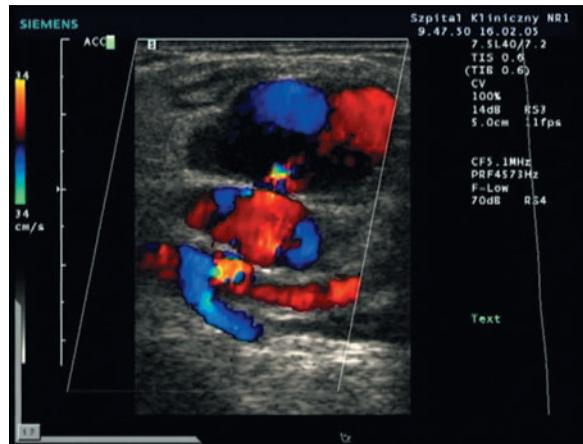


**Figure 3 a.** Pseudoaneurysm misdiagnosed as having only one cavity.

artery (SFA) was associated with successful result respectively in 83.2% and 66.3% of cases, whereas injuries to the external iliac artery (EIA) or the profunda femoris artery (PFA) were connected with significantly lower success rate, that is, 6.7% and 8.3%, respectively (fig. 4). We also noticed a significant difference in success rate depending on the localization of the entry in specific walls of the artery. In case of the anterior wall the success rate was best (87.5%). Significantly worse results were obtained when one of the lateral or posterior walls was injured (23.7% and 14.9%, respectively) (fig. 5).

**Discussion**

Although compression therapy, used as a first-line treatment option for pseudoaneurysms, is characterized by technical simplicity and low complication rate, its efficiency is limited and there are many contraindications. The most important ones include: shock, substantial compression of neurovascular bundle, limb ischemia and inflammation or necrotic skin lesions in groin [7, 11, 12]. The factors that limit the efficiency of this method to the largest extent are the use of anticoagulants during the peri- or postprocedural period and the time span between lesion forma-



**Figure 3 b.** The same pseudoaneurysm as in figure 3a in a control examination after 24 hours. There are two visible cavities supplied by an injured anterior wall of the superficial femoral artery.

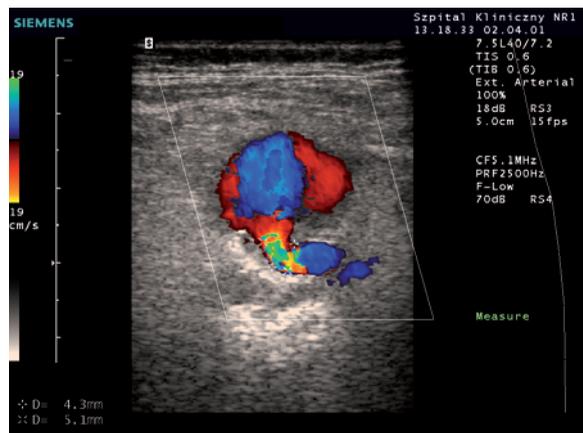
tion and beginning of the therapy [2, 13]. The importance of the aforementioned factors is doubtless and thus limits significantly the efficiency of all compression techniques. However, there is no consistent opinion about the influence of other listed factors, such as hypertension, obesity, old age, female gender and emergency procedures [1, 4, 14, 15, 16]. Some authors deny the importance of the factors mentioned above, or limit their influence to possible increase in the risk of iatrogenic complications after endovascular procedures.

However, as everyday practice shows, none of these factors, irrespectively of its statistical significance, is a reason to abandon treatment or prematurely stop compression therapy. This could lead to decrease in the number of patients who receive ineffective conventional treatment in the course of several days, which would lower the cost of treatment and limit inconvenience experienced by patients.

It seems that the parameters of IPA morphology determined in duplex Doppler examination could be chosen as these additional criteria [17]. It is a first-choice examination in



**Figure 4.** Pseudoaneurysm located posteriorly to the external iliac artery.



**Figure 5.** The entry of a pseudoaneurysm located in the lateral wall of the femoral artery.

case of clinical suspicion of complications after endovascular procedures, characterized by sensitivity and specificity similar to that achieved in contrast studies [15]. Additionally, as opposed to DSA and CT-A, it facilitates precise evaluation of lesion morphology [11].

In previous studies concerning the efficiency of treatment of pseudoaneurysms, usually only single parameters of IPA morphology were taken into account and their influence on the efficacy of specific therapeutic options was determined. The most often considered element was the size of the IPA cavity. Similarly to our observations, cross-sectional diameter of the cavity greater than 30-35 mm was shown to decrease significantly the efficiency of compression therapy [6, 18], whereas IPAs of diameter greater than 70 mm are indication to surgical treatment as first-line therapy [7]. Sackett claims that due to frequent occurrence of irregularly shaped cavities one should rather use pseudoaneurysm volume instead of diameter [18]. In his opinion, pseudoaneurysm yielding cavity volume greater than 30 cm<sup>3</sup> do not react positively to compression and this relationship is statistically significant. Only a few reports diminish the importance of cavity size as a prognostic factor for positive result of compression therapy [19].

Our observations show that the presence of thrombi as well as the degree to which they initially fill the cavities are not reliable prognostic factors for the efficacy of compression. The significant criterion is, however, the progression of filling the cavity by thrombi during the course of treatment. The increase in thrombus volume observed in subsequent control examinations is a good prognostic factor.

Apart from the size of pseudoaneurysm cavity, the number of cavities was proven to be important, too. Among 7 multiloculated pseudoaneurysms found in our patients, full embolization was achieved only in one case. According to Kruger, who observed a similar relationship, the difficulty in successful compression of this kind of pseudoaneurysms results from their infrafascial location, layered distribution of cavities, where superficial ones prevent compression of those more deeply placed and coexistence of extensive hematoma surrounding the pseudoaneurysm [20].

Relative easiness with which embolization of superficial pseudoaneurysm cavities is obtained suggests that compression therapy is more effective in case of pseudoaneurysms lying superficially under the skin. The natural boundary which significantly affects the effectiveness of compression techniques is the fascia. Even though IPAs located suprafascially are associated with a greater risk of hemorrhagic complications, compression therapy started early enough is successful in 100% of cases. The presence of one or more cavities in the infrafascial space makes the prognosis significantly worse.

The next considered element is the morphology of the canal which connects the artery with the pseudoaneurysm. Our observations, as well as previous studies [7], show that the results of compression therapy are better when pseudoaneurysms with long and thin canals are compressed. However, this relationship seems to be insignificant -

pseudoaneurysms adjacent to arterial wall in many cases responded very well to treatment. Additionally, the importance of this parameter is limited by difficulty in proper visualization of pseudoaneurysm neck in duplex Doppler examination. According to Moll, only in about 79% of cases the examiner was able to visualize and assess pseudoaneurysm neck in a reliable manner [1]. It was not possible to do so in the remaining cases, most often due to patient's obesity or extensive hematoma.

In our study, the blood flow in canals of IPAs that resolved with thrombosis after compression therapy was faster than in those treated without success. This proportion may be conditioned by longer and thinner canals of pseudoaneurysms susceptible to treatment. On the other hand, the studies of Moll et al. showed the distribution of blood flow velocity in the canals quite the opposite to our observations [1].

The important factor affecting the risk of formation of pseudoaneurysms as well as the efficiency of conservative treatment is the location of pseudoaneurysm entry in specific segments of the punctured arteries in the groin. The risk of IPA occurrence after catheterization of specific arterial segments is in a way a derivative of the efficacy of compression applied after the procedure and accounts for 13.6% in the EIA, 0.6-2.3% in the CFA and 4.1-4.6% in the vessels distal to CFA's bifurcation, that is the SFA and the PFA. The efficiency of compression therapy is highest in case of entry in the CFA (42-98%) and the SFA (30-85%). The location of entry in the PFA or the EIA is connected with significant limitations of compression treatment, its efficacy amounting to 2.9%-6.7% and 8.3%-16.6%, respectively [3, 14]. The differences described above are statistically significant. This appreciable scatter of results can be explained by variable locations of specific arterial segments with reference to the femoral head which acts as kind of support for pressure applied from above. Only the CFA and the proximal SFA run above the femoral head. Other arterial segments lie beyond the margins of the femoral head, which deprives them of proper support decreasing hemodynamic efficiency of exerted pressure [3]. In reference to the SFA, the situation is improved by superficial course of the vessel and shallower placement of pseudoaneurysms. Regardless of the location of entry in specific segments of femoral arteries, the kind of injured arterial wall is very important, too. Considerably worse prognosis is connected with trauma to one of the lateral walls or the posterior wall of the vessel. In the first case, especially, successful compression of the entry is almost impossible. Moreover, this location of lesion results very often from repeated puncturing of the vessel, which in consequence leads to extensive damage to arterial wall. Injury to the posterior wall, on the other hand, causes formation of a pseudoaneurysm located very deep, often coexisting with arteriovenous fistulas, which were found to be one of the fundamental causes of unsuccessful treatment with compression or thrombin injection [18].

## Conclusions

Among all the parameters applied in morphological assessment of iatrogenic pseudoaneurysms significantly, the

adverse prognostic factors for successful outcome of conservative compression therapy include: diameter (>30 mm) and cavity volume (>30 cm<sup>3</sup>), multiloculation of pseudoaneurysm, location of entry in the external iliac artery or the

profunda femoris artery, as well as in the lateral or the posterior wall of any artery. In all of these cases operative treatment should be considered as a first-line therapy, skipping the stage of compression therapy.

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