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COMPLICATIONS AND SOLUTIONS IN PROPELLER FLAPS SURGERY

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Abstract

Propeller Perforator flaps (PPFs) have long been proven as valid reconstructive tools, for a wide range of soft tissue defects in different body regions. During the last decade, despite their numerous advantages, many authors have thoroughly analyzed outcomes of these flaps, sometimes discouraging their use mainly because of a high failure rate. Accurate patient selection, adequate preoperative planning and an appropriate dissection technique seem to potentially improve outcomes.

Our manuscript provides a review of the relevant literature related to PPF complications and of our experience, describing reasons for failure, measures for preventing them, approaches for a prompt evaluation and management of complications.

Keywords:

Propeller flap, Perforator flap, Reconstructive surgery, Risk factors, Complications

Introduction

Propeller Perforator flaps (PPFs) represent an important reconstructive option which any plastic surgeon should be familiar with since they might be irreplaceable in certain situations. Since their advent, there have been consistent evolution and refinements of the surgical procedures, leading to their widespread use for different reconstructive purposes, in different body regions (1–8). Thanks to their extreme degree of customization, the ability of rotating up to 180° and the extreme length/width ratios that could be withstood by these flaps, the use of PPFs has revolutionized soft tissue reconstruction in several body regions (9–14).

Despite their increasing versatility and reliability which made PPFs a valid alternative to free flaps or multistaged procedures, it is important to be aware of the potential risks and complications related to their use (6,15,16). In the current literature, reported rates for PPF complications range from 8,3 to 42% (16–19), depending on the different anatomical sites, surgical expertise or variability of patient population.

This wide complications range, quite high in some series, can be justified by the nature of these flaps that rely on rather inconstant vascular anatomy both with regards to perforator position and perforator branching inside the flap.

The purpose of this manuscript is to clarify indications for propeller perforator flaps, identify reasons for failure and measures for preventing them, in order to eventually help in optimizing results using this highly precise tool we have in our hands.

Most Common Reasons For Failure

Surgical techniques and operative details have been described elsewhere in detail (7,10,18, 20).

Propeller perforator flaps are generally perceived as having a higher failure rate than conventional flaps. This is only partly true since the data need to be clustered to allow comparison. The highest failure rate is found in the region where propeller perforator flaps are likely to be most useful: the lower limb. Failure rates must also be considered in the light of the specific condition that is treated with PPFs: while an 8.3% failure rate is indeed be unacceptably high for a skin reconstruction in the trunk or face, it becomes relatively more acceptable in case of a complex post-traumatic lower limb reconstruction.

When one compares complication rates of PPFs (8,3% - 42%) (16,21) to those of other conventional/traditional flaps, like the reverse sural flap (up to 36%) (22,23), one would realize that it is not just the technique but the anatomical area itself (and the diseases/defects treated) that leads to high complication rates.

In this manuscript we will mostly refer to lower limbs flaps, taken as the reference since this is where PPFs are most useful and have the highest complication rates. Nevertheless, all the principles that will be explained in this manuscript do apply to all types of PPFs unless mentioned otherwise.

One of the most common reasons for failure of a propeller flap is a suboptimal indication. Although this might seem a very basic and obvious principle, too often, regardless of general and local conditions of the patient and the defect, a propeller flap is attempted even though it is not the best indication. Like any other surgical technique, propeller flaps require careful patient selection and appropriate planning. More than other techniques, propeller flaps need accurate intraoperative evaluation in order to determine whether they are feasible or not. This is due to the fact that these flaps rely on the presence of an adequate perforator and its ability to nourish the flap- and these conditions can only ultimately be verified intra-operatively sometimes under extreme conditions (e.g. up to 180° rotation). For this reason, the decision on performing a PPF cannot be taken preoperatively in all cases. Failure occurs when, despite inadequacy of the perforator to nourish the desired vascular territory or to withstand extreme rotations, a propeller flap is performed anyway. Unlike conventional/traditional flaps, which mostly have a well known, constant vascular pedicle with a known course inside the flap and a relatively well known size limit, PPFs have an inconstant anatomy. The desired perforator, usually found and chosen case by case can vary in size, location, number of veins, pulsatility, length or intramuscular/septal course case by case. Once a perforator of good quality is chosen, also the course of this perforator into the flap varies. If the flap is oriented according to the perforator subdermal and skin branching pattern, then vascularization is optimized. Failure to choose the correct flap design based on the course of the perforator, will result in failure even if the perforator is of good quality.

A very common reason for failure, specific of extremity flaps, is tension closure. Because propeller flaps are local, pedicled flaps, they have a limit in size, determined by local soft tissue availability. If the flap is not big enough to comfortably reconstruct the defect, then the flap will be closed under tension either on the pedicle or on the wound margins and skin of the flap (especially after postoperative edema has build up), causing an increased risk of perfusion related complications since when stretched, the vessels collapse. The skin of the lower limb has little redundancy, scanty subcutaneous tissue, numerous septa and little elasticity. As a consequence, postoperative swelling is poorly tolerated. To withstand postoperative swelling, flap sizes shall exceed defect sizes, since if a flap is not wide enough to accommodate postoperative swelling, swelling and tension will make the capillaries collapse and eventually the flap will fail, mostly partially (24,25). Even if well perfused at the

end of the procedure, a flap that is just big enough for the defect will be unable to accommodate postoperative swelling and fail subsequently.
As already mentioned above, due to the variability in anatomy and function of the perforator vessels, when planning a PPF alternative flaps, like traditional flaps or even a free flap, shall be planned in advance and used in case of doubts about the adequateness of a PPF(9,26). Intraoperatively, the factors to be evaluated are perforator position, size, length, pulsatility, veins presence and quality, intraflap perforator branching, donor tissue availability. If these factors are not favorable, or, although adequate, the flap seems not well vascularized or vascularity is compromised by rotating and/or suturing the flap, the PPF should be abandoned and an alternative flap used. Failure to do this, may lead to flap necrosis.
Reasons for failure are most commonly regarded as extreme length width ratios and torsion of the pedicle (25,27). Was this true in every case, then long and narrow flaps rotating 180° shall not be surviving at all. But they survive instead, despite extreme arcs of rotation (180°) and length/width ratios (4/1 to 6/1) (7,19). The size of the flap or the degree of rotation may not be the only explanation for propeller flap failure. An extremely large perforator, despite high flow and robustness, may fail to nourish a flap that is located away from its perforasome. No definitive guidelines nor mathematic rules on flap size have been established to warrant safety of perfusion of PPFs. The vascular territory of a certain perforator, the perforasome, is an extremely important factor (28). Though, when referring to perforasomes, it is important to distinguish the concept of arterial and venous ones. Unlike the arterial equivalent, the venous perforasome is dynamic, varies individually from patient to patient and can be influenced by different concomitant conditions (comorbidities, hemodynamic status) (29). Consequently the venous perforasome is difficult to define anatomically and a poor management can easily lead to problems with venous drainage.

Patient Selection: Identification of Risk factors for Complications

Identification of all those conditions that are related to an increased risk of flap failure is the first step to select the right target of population. These conditions can be evaluated preoperatively and poor candidates to a PPF can be identified in advance (Tab. 1).

Despite the well-known high rate of complications associated to PPF, frequency and risk factors for complications have not been studied thoroughly. The few studies on this, concentrate on cases of lower extremities reconstruction (17,30).

Among the different body areas, PPFs used for reconstruction of extremities resulted to be at higher risk of complications, particularly when considering lower limbs (17,19,27). The larger-sized flap harvest in the trunk area could be considered safer because of the numerous perforators and wider perforasomes present in this area (28,31); in the extremities, the shorter perforators combined with the presence of scarce and compact subcutaneous tissue require more intramuscular dissection and skeletonization, to elongate the pedicle and reduce the effects of its torsion on blood flow. Vascular compromise (17, 29,32) may be also related to the surgical technique used for perforator dissection.

History of irradiation in the area of flap harvest is a significant risk factor (27). Radiotherapy induces modifications either in skin and in vessels, with intimal or adventitial alteration resulting in cases of thrombosis and obstruction(33). At the same time, the atrophic and fibrotic changes induced in the surrounding tissues, make a more aggressive dissection necessary, compromising the safety of perforators (27).

The meta-analysis conducted by Bekara et al (30), showed that advanced age (>60yo), diabetes mellitus and peripheral arterial disease are strongly associated to an increased risk of flap complications and it was suggested that this high risk patient category should be excluded from PPF reconstruction. According to other studies results, this association is somehow controversial and there is not always significant relationship between comorbidities and flap complications (17,27,34). These controversial data do not allow to identify absolute contraindications. However, the relative contraindications extrapolated from these studies (listed in table 1) may be used as a guide to select patients.

Many authors question the safety of PPF in cases of large skin flaps and 180° rotations. However, giant flaps with extreme length/width ratios and 180° rotations have been shown to survive completely (19). It has, however, been shown that higher rates of complications are correlated to higher arc of rotations (>150°) in the extremities (27). As already partly mentioned in the previous paragraph, in the extremities, the poor subcutaneous tissue together with tissue adherences and short perforators bring to a higher risk of vascular compromise when dissection is not properly performed (27).

→ ***Higher risk patients category: Peripheral arterial obstructive disease (PAOD)***

In patients with peripheral arterial obstructive disease (PAOD) the precarious state of health given by the presence of multiple comorbidities, such as high blood pressure, stroke history, coronary disease, renal failure or diabetes mellitus must be carefully taken into account in major surgical reconstructions.

Specifically, patients with stage IV PAOD presenting with severe ischemic ulcers often associated to bone, tendon, or artificial material exposure are significantly threatened by major amputations. In this high risk patients category, a combined approach either in the preoperative and intraoperative setting between vascular and plastic surgeons, is crucial for the success of any surgical strategy (35,36). The classical and successful use of free flap reported in the literature for reconstruction of tissues defects caused by critical limb ischemia, is accompanied by dangerous postoperative complications derived from poor general conditions and by microsurgical technical problems, due to calcified or atherosclerotic vessels. In these cases, the use of a surgery with low donor site morbidity and shorter operative time would reduce risks (37). As shown in the retrospective study of Jiga et al (37), perforators propeller flaps (PPF) can be a valid surgical option for lower limbs defects in patients with stage IV PAOD, offering a reliable and adequate one-stage reconstruction. A standard protocol that includes initial revascularization followed, after a mean period of 2 weeks, by tissue reconstruction through PPF, can be successfully applied to this high-risk category(35). Once vascular reconstruction is carried out, tissue reconstruction can be performed as for any other patient.

When performing a PPF in PAOD patients, the perforator of choice on which to build the entire flap usually arises from the major vascular axis, used for revascularization. This is however not a "*sine qua non*" condition for PPF harvest. Alternative locations of the skin flap can always be considered, planning the flap on another main vascular trunk, which, even if it is not the main run off vessel, can present sufficient blood flow, thanks to a valid anastomosis network connecting the three main vascular axis of the leg (37,38). These conditions shall be checked preoperatively with an angio CT/MRI or angiography (39,40).

Complications Avoidance and Treatment

Having clarified the need for accurate pre and intraoperative planning (Fig.1), we seek to analyze in the following paragraphs the main complications that can be encountered with PPF reconstructions. For each we have scrutinized two fundamental aspects:

- Technical errors which could be avoided with a more accurate preoperative planning;
- Possible management algorithms of considered complications (Fig. 2) ;

➢ **Arterial Insufficiency**

Arterial insufficiency in flaps in general is relatively less common when compared to venous insufficiency. However, it is likely more common that what is generally perceived, or at least it is given less relevance. Most authors attribute the cause of failure to a pedicle torsion that causes vessel (arteries) occlusion (7,9,41): this can be true indeed but we have also observed that arterial insufficiency can be most common than what is generally believed, not only because the perfusion pressure of the perforator is insufficient, but also – as mentioned above - because the flap is located away from its vascular territory. In cases of arterial insufficiency the flap (or part of it) becomes pale and cool due to reduced arterial inflow, with slow or absent capillary refill. This situation is very often due to spasm induced by vessel dissection during flap harvest and in most of the cases is immediately observed. If this is the case, temporary spasm is often reversible. However, inaccurate dissection might cause intimal damage causing an irreversible arterial insufficiency to the flap. Differential diagnosis can be made with the aid of an intraoperative Doppler or ICG study or just because the spam won't spontaneously settle.

An absent or insufficient arterial inflow can also derive from incorrect surgical planning or presence of a unexpected anatomic variability which cannot be appropriately managed. Sometimes, arterial insufficiency can occur postoperatively, as consequence of compression or tension created by an hematoma or tension caused by swelling due to edema.

→ ***How to avoid it***

Most of the times a correct preoperative planning can avoid occurrence of arterial failure. Three are the basic factors one should always consider:

1. Making the choice of the best perforator, according to its caliber (largest), good pulsatility, course, and proximity to defect (7).

Perforator identification is a crucial step.

According to the two major studies that gave a broader understanding of the vascular anatomy, by Taylor and Palmer, for angiosomes, and Saint-Cyr for perforasomes, it is advisable to apply the following rules (2,9) (Fig.3):

- Select perforators close to the midline or main joint of the limb;

- Skin flap orientation along the main source vessel axis or a line connecting two perforators;
- Skin flap main axis oriented parallel to lines of growth of the body area considered;

Perforators can be found with confidence in any part of the body. More precise location of vessels must be achieved with perioperative use of a handheld Doppler. In the absence of a signal and preoperative perforator mapping, dissection can become more time-consuming and tricky.

2. Perform a sufficient and wide exploratory incision.

In any case, it is always advisable to perform the initial incision only on one side of the planned flap design, in order to eventually retailor the flap according to the main perforator identified intraoperatively and thus not to interfere with alternative reconstruction options in case of need (Fig. 4). In all cases, the exploratory incision must be long enough to allow good exposure and control of the pedicle, but should also respect of surrounding tissues that may represent the donor side for harvesting the "plan-b" flap (9).

3. Perform a proper dissection, releasing the pedicle from any surrounding fascial attachments while staying away from direct manipulation of the perforator itself.

After an accurate mapping, it is important to proceed with a standardized approach and through an atraumatic dissection of surrounding tissues to avoid unintentional damages.

If on one hand preoperative mapping through Doppler examination can be helpful, on the other hand nothing can replace intraoperative exploration and observation. Especially when considering lower extremities, perforators often have a tricky course, presenting a long suprafascial portion between the exiting point from the fascia and the cutaneous end point where the Doppler signal is marked (9). Therefore, when proceeding with dissection, always keep in mind such circumstance, without giving up searching for the perforators that will be located just further from the level of acoustic Doppler signal.

Based on the course of the perforator, the skin island of the flap can be re-drawn during the operation in order to have the course of the perforator as major axis of the flap.

If arterial insufficiency is likely due to spasm, an important intraoperative step consists in leaving the flap circulation to settle (20 minutes waiting time with the flap wrapped in a warm moist gauze) before flap transfer. During this time, local vasodilating agents such as papaverin, lidocaine or Prostaglandine E2 can be used to irrigate the pedicle. We normally harvest the flap before debriding or working on the recipient site. While on one hand this strategy mandates error-free planning of the flap, on the other hand gives the flap time to settle. Shall this intraoperative waiting time be insufficient, or shall rotation worsen the inflow, the flap can be left in place or de-rotated and the operation staged and be postponed by a few days in order to let vascularity stabilize (9).

If available, NIR (near-infrared) fluorescence imaging system after ICG (indocyanine green) injection can represent a useful diagnostic tool to evaluate flap perfusion and even perforator course before flap harvest compromised perfusion and can help in guiding intraoperative decision (42).

→ ***How to treat it***

A “wait and see” policy, that gives the time to the circulation to settle down and to the spasm to solve autonomously, without need of any treatment or reintervention. Specifically, the flap can be left in place or brought back to its original position, for approximately 15-20 minutes or more, and irrigated with local vasodilating agents (e.g. lidocaine, papaverine or PGE2) until resolution of the capillary pulse and flap turgor. If, after all these measures, the spasm doesn’t resolve, the flap must either be resutured in its original position for 2-3 days and wound reconstruction delayed or the flap shall be completely abandoned and the “plan B” flap be used. After 2-3 days, if inflow is insufficient, impending necrosis will be well visible and subsequent decisions can be taken accordingly. If spasm has settled, then the flap can be safely transferred. Shall there still be too much edema, edema shall be allowed to re-absorb over additional days. Intraoperative conversion to a free flap is always an option shall this additional burden be judged untolerable for the patient.

In some instances partial flap insufficiency can be caused by tension closure. Stitches removal can be useful in these particular cases to relieve the tensions that impairs blood flow. Such a scenario is usually very apparent since a clear demarcation line, sometimes a deep furrow, is seen in between two stitches.

We have observed (unpublished data) that vascular impairment can often be seen on a picture before it is clinically apparent. We always have a picture taken intraoperatively to have a look at the flap to double check vascularity before waking the patient up.

Even if their use is off-label in perforator flaps surgery, nitroglycerin ointment or glyceryl trinitrate transdermal patch, acting as vasodilatator agents, can be advantageously used when arterial or venous blood supply are compromised (43). They can be used postoperatively either to help flaps before transfer when the decision has been to stage them, or in cases of compromised flow at the tip when no other measures are available.

The treatment of choice for arterial insufficiency is arterial supercharging. If it is not reversible, and thus not caused by spasm, arterial insufficiency is caused by the flap extending beyond the vascular territory of its perforator. As described by Pignatti et al., accessory perforators shall be preserved towards the tip of the flap as possible (25). If the perforator itself is insufficient to nourish the flap (as judged by clinical examination alone or demonstrated by INR fluorescence after ICG administration), then anastomosis of an accessory pedicle (supercharging) will resolve insufficiency (44).

Hyperbaric oxygen therapy (HBOT) has been described to improve vascularity or avoid further worsening of the flap (45).

- **Venous Insufficiency**

It is generally believed to be the most common complication occurring in PPF surgery (17,46): the venous outflow obstruction determines a dusky pink to dark blue discoloration and an accelerated capillary refill or engorgement of the flap, that subsequently becomes swollen ultimately worsening the problem.

Given the different structure of veins that consist of less robust and thinner wall than arterious vessels, venous congestion is more easily related to pedicle compression. Most of the times, venous congestion is derived from mechanical causes such as hematoma, edema, excessive tension in wound closure (25); other times can be a consequence of kinking or twisting of the pedicle, wrong dissection manoeuvres with damage to the perforating veins or disruption of superficial venous system during flap harvesting and elevation (27).

Venous congestion can be transient and slowly get better as soon as the flow settles down or it may gradually worsen to cause flap failure.

→ ***How to avoid it***

The only way to minimize the occurrence of venous insufficiency is to accurately check the presence of one or two good veins in the pedicle and perform a perfect dissection in order to avoid damaging them.

Pedicle dissection, especially when rotations of more than 90° are necessary, shall be extended to the whole perforating branch, up to the source vessel, to better distribute torsion across a longer pedicle segment (41,47). When in doubt, considering the dynamic nature of venous perforasomes, that may show some adaptability and extend their territory, a delay procedure in cases of venous congestion can help to evaluate its evolution (48).

In view of high rate of venous congestion at the level of forearm, we advocate the routine use of venous superdrainage to warrant sufficient venous drainage output (9).

→ ***How to treat it***

Prevention starts during flap dissection: all superficial veins and at least one accessory perforating pedicle shall be preserved in case the one that is chosen as main pedicle is insufficient and supercharging becomes necessary.

If venous insufficiency is recognized, intra or postoperatively (re-exploration is mandatory in the latter case since it might be due to a reversible event that has occurred postoperatively), and supercharging is considered, three criteria shall be fulfilled before performing supercharging: there must be venous insufficiency (congested flap), in presence of a dilated superficial vein or perforating vein and opening of that vein to let it drain must solve congestion. If the vein is full but the flap is ok, if the flap is congested but the vein is empty and is not draining, if the vein is empty and drains, but despite drainage through the vein the flap does not improve, venous supercharging is not indicated (Fig.5).

When superficial or perforating veins are empty and opening them does not improve the flap, supercharging is not indicated. Flap de-rotation and leeches shall be considered in these cases.

If these measures are unavailable, then leech therapy is the only option. HBOT has been reported as an adjunctive therapy can be of support within first 10 days (45).

Sporadic reports of VAC application to the flap can be found in the literature to help with venous insufficiency (49).

- **Partial/Complete Necrosis**

Flap necrosis is the result of a vascular compromise. It can be partial, starting from the distal and less vascularized portion the flap, and it may involve the skin alone or the full thickness of the flap. Complete flap loss is very rare. However, since the part that suffers is normally the tip of the flap, the distal most part used to cover the defect, a partial flap loss – differently than a free flap – is often a complete failure (Fig.6).

If not readily treated it can bring to local infection, with worsening of general conditions and involvement of deep structures.

→ ***How to avoid it***

A good intraoperative planning that aims at removing of all those conditions or factors that increase tension on the pedicle are fundamental to prevent this type of complication. All the measures described above shall also be used.

Application of external fixation may be very useful, particularly when using propeller flaps for reconstruction of soft tissue defects in the middle-third to distal lateral leg. Immediately after harvesting, the worst perfused area in a propeller flap is its distal skin island furthest away from the main perforator. Therefore a tension-free suture becomes important to prevent necrosis and secondary wound break-down at this level. As the skin envelope of this body region is well known for its lack of elasticity, achieving a tension-free suture of the flap into the defect at the level of the the distal wound, might be difficult. This phenomenon occurs when either the position of the main perforator, its perforasome or other given particularities (e.g. previous scars, chronical contractures, concommitant wounds) prevent recruiting enough skin into the flap to assure an ideal length. Moreover, in the lateral distal shank, perforators from the anterior tibial or peroneal artery can have a complete intramuscular course, circumstance under which, postoperative immobilization of the next distal joint (e.g. ankle) becomes mandatory to prevent possible tension on the perforator from contracting muscles of the anterior or lateral compartments (Fig.7a). In such situations, an external fixator, placed over the ankle joint (usually two pins in the tibial shaft and one pin into the medial cuneiform bone of the foot will suffice) fixing it into a 90 degrees position, can remove a considerable amount of tension in the distal flap while providing a solid immobilisation of the entire reconstructed segment during the first postoperative period. Additionaly, using a simple bed-extension device, the entire shank can be suspended on the external fixator, maneuver which is particularly useful for defects located at the level of the lower leg as it also prevents possible external pressure on the flap and allows an easy postoperative monitoring (Fig.7b). The external fixators are removed on the postoperative day 5 under light sedation, the pin wounds are left to heal spontaneously. Altough lacking sufficient evidence and appearing as a very aggressive procedure, the external fixators are very efficient tools to increase the success rate of both local propeller as well as free perforator flaps in the lower extremity, either by directly removing tension on the wound edges or by preventing dangerous external pressure points on the flap (e.g. pedicle) expecially during the first postoperative period and thus allowing an optimal immobilisation to promote an uneventful healing. Additionaly, with the proper training, this technique yelds practically no complications (unpublished evidence of the authors in over 1200 free and local perforator flaps in the lower extremity over six years period).

→ ***How to treat it***

In case of partial necrosis, the flap is normally left in place and an eschar is allowed to develop, as long as infection doesn't occur. After debridement, an adequate layer of granulation tissue often covers the wound bed that can either be improved by VAC therapy or directly skin grafted. If this is not the case, another flap shall be used.

In case of full-thickness necrosis, another flap will be necessary.

Conclusions

Despite representing a valid surgical option for reconstruction of any body region where a perforator can be found, PPFs present a consistent rate of complications that should be taken into account when considering this surgery. Factors such as appropriate patient selection, good anatomical knowledge, good preoperative plan, accurate intraoperative dissection technique, adequate local conditions, play a critical role in determining successful outcomes.

The relative lack of literature focusing specifically in the management of complications and creation of guided algorithms for their solution, leads to confusion and wrong assumptions. Application of standardized protocols and techniques can bring to avoidance of common mistakes and at the same time to a prompt identification and resolution of problems.

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FIGURE CAPTIONS

Fig. 1 – Algorithm for prevention of complications.

Fig. 2 – Algorithms for management of vascular compromise (arterial (a) and venous (b) insufficiency).

Fig. 3 - (a) Intraoperative picture of a PPF ALT flap of the right thigh. The knee is on the right side. The two perforators chosen are marked with an "x"; the intraflap course of the proximal perforator is marked on the skin. The second perforator in these cases should not overlap with the vascular territory of the first one, but rather nourish the distal most portion of the flap, at highest risk of ischemia. (b) Intraoperative picture of the flap shown before transfer. The knee is on the right side, medial is above. In this case, the two perforators nourishing the flap are anatomically connected to each other. If no anatomical interconnection between the two perforasomes exists, one of the perforators can be supercharged through an additional arterial microanastomosis at the recipient site. (c) 3 months postoperative view, showing complete flap survival.

Fig. 4 – (a) Intraoperative view of a Medial intercostal artery perforator flap seen from a caudal view. Medial is on the right hand side. The perforator has been identified from the edge of the surgical defect after resection of a large Squamous Cell Carcinoma. The course of the perforator can be clearly seen inside the flap and it shall be used as guide to avoid incorrect orientation and optimize perfusion. In most cases, the course parallels that of a cutaneous nerve. The blue vessel loupe is placed parallel to the vessel (and nerve) to highlight its orientation. (b) Intraoperative view from a cranial view (medial is on the left hand side). Only once the orientation of the perforator inside the flap is well known one can commit to complete flap incision.

Fig. 5 – (a) Immediate postoperative view, of a radial artery PPF (the elbow is on the right hand side, bottom is lateral) with evidence of dark blue discoloration at the distal part of the flap. When venous congestion is progressive and doesn't resolve spontaneously, a re-exploration is necessary. The superficial vein (routinely preserved during flap harvest) was full of blood at re-exploration and, when opened, drained efficiently, making the flap look well perfused again. This is the indication for venous supercharging. (b) Close up view of the superficial vein after anastomosis. (c) 1y postoperative view showing complete flap survival.

Fig. 6 - Progressive "3-zones" necrosis in a 57 yo patient with Peripheral arterial obstructive disease (PAOD) after PPF reconstruction of the exposed left lateral ankle. The PPF was based on a perforator from the peroneal artery after prior endovascular recanalisation (percutaneous transluminal angioplasty) of the tibioperoneal trunk.

Fig. 7 – (a) Propeller flap on a perforator of the peroneal artery to cover a defect of the distal lateral shank in a PAOD patient. The perforator proved to have a complete intramuscular trajectory (white arrow), circumstance under which the vessel should be carefully and extensively mobilised by identification and ligation of several intramuscular branches, thereby gaining the required length to avoid possible over-traction during flap insetting. (b) PPF has been rotated 180 degrees and sutured into the defect. By using an external fixator placed on the tibial shaft and the medial cuboid, that fixes the ankle at 90 degrees, one can easily identify the skin wrinkles (small arrows) as a clear sign of skin detensioning direction (dotted arrow) and thus offloading of the distal suture line between the defect and the distal edge of the flap.

TABLES

Tab. 1 - Identification of risk factors (24,27,34) to select the right target of population

PREOPERATIVE RISK FACTORS
Diabetes Mellitus
Peripheral arterial obstructive disease (PAOD) *(not treated)*
Advanced age (>60yo)
History of radiotherapy
Inadequacy of perforators
Extensive trauma and scarring