Diabetic foot disease in the elderly

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Abstract

Elderly diabetic patients are particularly burdened by foot disease. The main causes for foot disease are peripheral neuropathy, foot deformities and peripheral arterial disease (PAD). Other risk factors include poor vision, gait abnormalities, reduced mobility and medical co-morbidities. The risk of major amputations increases with age, along with the increased prevalence of these risk factors. The true risk of amputation and other burdens of foot disease in the elderly are likely underestimated by current epidemiological data. The prevalence of neuropathy, foot deformities and PAD as well as the risk of amputation all increase with age even in non-diabetic patients. The principles of prevention and management of diabetic foot disease may also apply to large segments of the elderly non-diabetic population.

Foot ulcer prevention relies on the identification of high risk patients and avoidance of triggering events, such as ill-fitting shoes, walking barefoot or poor self-care. PAD is a major cause of amputation and should be prevented by lifelong attention to glycaemic control, treatment of hypertension and dyslipidemia, and avoidance of smoking.

The treatment of foot ulcers relies on pressure relief (off-loading), wound debridement, and treatment of infection and ischemia. It requires an individualized approach considering the patient’s co-morbidities and functional status. Off-loading remains essential, but devices such as total contact casts or crutches can only rarely be implemented. However, providing adapted standard foot-wear and insisting on its consistent use even at home is often effective. The benefits of aggressive vascular or orthopaedic surgery should be weighed against the risks of prolonged hospitalisation and resulting functional decline. Greater attention to prevention and individualized care are needed to reduce the burden of diabetic foot disease in the elderly.

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Résumé

Le pied diabétique du sujet âgé.

Les patients diabétiques âgés sont particulièrement affectés par les complications au niveau du pied. Les principales causes d’atteintes du pied sont la neuropathie périphérique, les déformations du pied et les artériopathies des membres inférieurs (AMI). Les autres facteurs de risque incluent les troubles de la vision, les troubles de l’équilibre, une mobilité réduite et les co-morbidités médicales. Le risque d’amputations majeures augmente avec l’âge, avec l’augmentation de la prévalence de ces facteurs de risque. Le réel risque d’amputation et le poids des atteintes du pied chez les personnes âgées sont très certainement sous-estimés par les données épidémiologiques actuelles. La prévalence de la neuropathie, des déformations du pied et des AMI, tout comme celle du risque d’amputation, augmentent toutes avec l’âge, même chez les sujets non diabétiques. Les principes de prévention et de prise en charge du pied diabétique peuvent donc s’appliquer également à une large part de la population des sujets non diabétiques.

La prévention des ulcérations du pied repose sur l’identification des patients à haut risque et sur des mesures cherchant à éviter les événements déclencheurs, tels un mauvais chaussage, la marche à pieds nus ou une hygiène insuffisante. Les AMI sont une cause majeure d’amputation et doivent être prévenues par une attention permanente au contrôle glycémique, au traitement de l’hypertension artérielle et des dyslipidémies, et à la suppression du tabagisme.

Le traitement des ulcérations du pied repose sur la levée des hyperpressions par la mise en décharge du pied, le débridement des plaies, et le traitement de l’infection et de l’ischémie. Il nécessite une approche individualisée, prenant en compte les co-morbidités et les capacités fonctionnelles du patient, qui demeure une mesure essentielle. Malheureusement, les moyens pour la mise en décharge que représentent les chaussures et les plâtres de décharge totale ou les béquilles de soutien ne peuvent être que rarement utilisés. Toutefois, la prescription de
Introduction

Foot disease is one of the most serious and costly complications of diabetes worldwide. In recent years, major progress has been in the recognition of the problem and in the understanding and management of the disease. Foot complications usually result from the interplay of several causes including neuropathy, foot deformities and peripheral artery disease (PAD). Although foot disease often occurs in elderly patients, the impact of age on its presentation, treatment and prognosis have been little studied. In this review, we will attempt to discuss diabetic foot disease with an emphasis on the specificities of the disease in elderly patients.

1. The epidemiology of Diabetic Foot Disease

The prevalence of diabetes is rapidly increasing worldwide and a real epidemic of the disease can be expected in the 21st century. The World Health Organization (WHO) has estimated the prevalence of diabetes for all age-groups worldwide to be 2.8% in 2000, which correspond to a total number of 171 million of patients [1]. This number will more than double and will reach 366 millions in 2030. This increase is as much related to the aging of the population as to the rising incidence of obesity [1]. In elderly patients (>65 yrs) the prevalence of diagnosed diabetes is approximately 6-10% [2-5]. An additional 10% have undiagnosed diabetes [6]. A substantial and increasing proportion of the elderly population is therefore at risk of micro- and macrovascular complications, including diabetic foot disease.

In population surveys, more than 5% of diabetic patients have a history of foot ulcers [7]. Further, the lifetime risk of a person with diabetes for developing a foot ulcer is estimated at 15-25% [8-9]. The worst and most feared outcome of diabetic foot ulcers is Lower Extremity Amputation (LEA). Diabetes continues to be the leading cause of LEA worldwide. A foot ulcer precedes and is responsible for 85% of all LEA in the diabetic population [10-12]. Fifteen to 27% of all ulcers result in surgical removal of bone [13-16]. WHO has estimated that there are approximately 250,000 LEA per year in diabetic patients in Europe, of which two-thirds are in former Eastern European countries. Age was considered as only a minor risk factor for LEA in different clinic-based or small population studies [17-20]. However, a study comparing centres from 10 countries, observed a wide range in incidence of major amputations (3 to 40 per 100,000 persons per year in the whole population). The relative risk of amputation was at least five times higher in old (>80 years) than in younger (40-59 years) subjects. About two-thirds of amputations are performed in patients aged over 60 yrs [21]. Two important population studies separating diabetic and non-diabetic persons also reported a striking increase in the incidence of major and minor amputations in elderly patients with a rate exceeding more than 500/100,000 diabetic persons per year [22-23].

The incidence of amputation is not necessarily a sufficient indicator of the importance of diabetic foot disease, nor a reliable marker of the quality of care. Most studies suffer drawbacks in the quality of case recording. This was shown by the significantly higher incidence of amputation determined by prospective identification, compared to retrospective identification in the same centre [24]. Reliance on surgical records or discharge coding is known to understate the true incidence of amputation [24-25]. Further, the details of the levels of amputation are not reported in an uniform manner, making studies hard to compare. The indications considered for amputations may vary substantially between care centres (which put variable emphasis on conservative care), and be influenced by the patient’s age and prognosis. Increasingly, minor distal amputations are performed as part of the care of diabetic foot ulcers, and meant to prevent further amputations at a higher level [26]. Such procedures are likely carried out less frequently with increasing age. Even the indications for major amputations (trans-tibial or trans-femoral) may be affected by the patient’s overall prognosis. In particular in very old patients, conservative, palliative management of pain and infection may be preferred. Conversely, amputation itself may be seen as part of a palliative care approach, improving the patients’ symptoms (e.g. ischemic pain) and simplifying nursing. Thus, the incidence rates of major amputations among elderly patients are not a sufficient indicator of the quality of care. One essential, unanswered question is whether delaying amputations improves the quality of life or just prolongs the pre-amputation period of active wound care and morbidity (e.g. pain). This question will only be answered by a prospective study using predefined criteria for amputation and evaluation of quality of life before and after amputation [27]. Finally, it is important to emphasize that the burden of diabetic foot disease in the elderly is obviously not limited to the risk of amputation, but includes...
peripheral neuropathy in diabetes differ considerably, partially because of the lack of a consensus on basic definitions and differences in patient selection and diagnostic procedures. Accordingly, prevalence rates vary between 5 and 100%! [32-34]. The studies reporting the highest prevalence are based on nerve conduction studies. Other risk factors include microvascular complications, increasing duration of diabetes, poor metabolic control, insulin treatment, peripheral edema, skin atrophy, low socioeconomic status, and most predictive of all, a past history of foot ulcers or amputation [31].

2. The pathophysiology of diabetic foot disease

2.1. Diabetic foot disease is a multi-factorial process

The main factors involved in foot-related problems in patients with diabetes include peripheral sensorimotor and autonomic neuropathy, high foot pressures resulting from foot deformity, PAD and limited joint mobility (Figure 1). The elderly may be at particular risk because of poor vision and reduced mobility, especially at the hip which impairs their ability to inspect the feet correctly and regularly, and leads to the continued progression of foot lesions. Other risk factors include microvascular complications, increasing duration of diabetes, poor metabolic control, insulin treatment, peripheral edema, skin atrophy, low socioeconomic status, and most predictive of all, a past history of foot ulcers or amputation [31].

2.2. Peripheral Neuropathy

Peripheral neuropathy is the essential cause of diabetic foot disease. Reports on the incidence and prevalence of peripheral neuropathy in diabetes differ considerably, partially because of the lack of a consensus on basic definitions and differences in patient selection and diagnostic procedures. Accordingly, prevalence rates vary between 5 and 100%! [32-34]. The studies reporting the highest prevalence are based on nerve conduction studies. The cohort study of Pirart on 4,400 cases found an evidence of neuropathy in 8% of patients at diagnosis. After 25 years of diabetes, 50% of patients had signs of neuropathy, defined as abnormal reflexes and vibratory sensation [35]. In a large multicentre study, more than half of all patients with type 2 diabetes admitted to hospital, aged over 60, were found to have neuropathy [36]. Features of neuropathy are increasingly found in old age, even in the absence of diabetes. In a population of patients >65 yrs in a primary care setting, peripheral sensory neuropathy was detected by simple physical examination in 31%; two third of them had no history of medical conditions known to cause it [37]. These observations indicate that aging per se may induce the loss of touch and pain sensation, and may be other features of neuropathy.

The role of neuropathy in the pathogenesis of foot ulcers is complex. Sensory neuropathy causes the loss of touch and pain sensation, which are essential for the avoidance of excessive foot pressure and shear stress. Motor neuropathy causes foot muscle atrophy [38] and thus favours limited joint mobility and foot deformities such as claw or hammer toes, hallux valgus/rigidus, or prominent metatarsal heads. Theses deformities, even in absence of physical activity (e.g. walking) are sites of elevated pressure or shear stress which may precipitate ulcer formation, especially in presence of ill-fitting shoes or other minor trauma. The focal increase in pressure in the foot sole or other deformities leads to the formation of hyperkeratosis i.e. callus formation. Callus is more frequent in diabetic patients than in their non-diabetic counterparts [39]. The impact of hyperkeratosis on plantar pressure is dramatic [40] and plantar callus and diabetic foot ulceration are strongly associated [39]. Although there are surprisingly few data on the detailed type of foot lesions according to age, clinical practice suggests that foot ulcers are less frequently associated with plantar

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**Fig 1. Causal pathways to foot ulceration in the elderly**

- **Age**
- **Diabetes**
- **Neuropathy**
- **PAD**
- **Sensation**
- **Motor**
- **Autonomic**
- **Cellular Ischemia**
- **Foot Ulcer**
- **Elevated Plantar Pressure and/or Shear Forces**
- **Callus**
- **Limited Joint Mobility and Foot Deformity**
- **Foot Muscle Atrophy**
- **Gait Abnormalities**
- **Reduced Plantar Soft Tissue Thickness**
- **Reduced Mobility**
- **Footwear**
- **Trauma**
- **Inappropriate footwear**
- **Poor vision**
- **Reduced mobility**

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2.3. Peripheral arterial disease (PAD)

2.3.1. Epidemiology of PAD

PAD is a key risk factor for ulceration [46]. PAD also impairs healing of existing diabetic foot ulcers. The wound classification proposed by Armstrong et al considers ulcer depth, infection and ischemia; the contribution of ischemia to poor outcome (non-healing ulcer or amputation) was clearly demonstrated in the validation studies of this classification [16]. In Geneva (Switzerland), virtually all major non-traumatic amputations are performed in the context of severe ischemia, suggesting that ultimately severe ischemia is by far the main cause of non-avoidable amputations [25]. PAD is a highly prevalent disorder in elderly populations. In epidemiological studies, PAD is usually diagnosed by the presence of an ankle-brachial index (ABI) <0.9. In several population studies performed in patients >55-65 yrs, the overall prevalence of PAD is approximately 20% [47-49]. However, the prevalence increases with age and may exceed 40% in patients >85 yrs [48, 50]. PAD is strongly associated with diabetes, hypertension and smoking. In the UKPDS (United Kingdom Prospective Diabetes Study), glycaemic control is a much stronger predictor of PAD than other atherosclerotic disorders, suggesting that peripheral arteries are more sensitive than other large vessels to the detrimental effects of hyperglycaemia [51-52]. The presence of intermittent claudication underestimates the prevalence of PAD. Indeed, less than half of all patients with an ABI<0.9 have claudication. It is often stated that the presence of peripheral neuropathy attenuates the symptoms of PAD in diabetic patients. While likely, this notion is poorly demonstrated. The proportion of patients with asymptomatic PAD is not strikingly different in diabetic and non-diabetic populations [47-49]. Even in the absence of symptoms, PAD is associated with a high risk of cardiovascular events such as stroke, myocardial infarction and cardiovascular death [53-54]. It is likely that PAD is a marker of diffuse atherosclerosis, and as such is predictor of cardiovascular risk factors such as obesity, hypertension and dyslipidemia [55].

2.3.2. Diagnosis of PAD

The diagnosis of PAD not only identifies patients at high risk of foot ulceration, but also predicts a high risk of cardiovascular events and provides an opportunity to elicit and treat symptoms of PAD. Given all these potential benefits, screening should be carried out liberally in elderly and/or diabetic populations. Since the absence of claudication or other symptoms fails to rule out PAD, the detection of PAD relies on physical examination and measurement of the ABI. The presence of an iliac, femoral or popliteal bruit or the absence of any pulse (femoral, popliteal, posterior tibial and dorsalis pedis) greatly increase the likelihood of a low ABI (reviewed in [56]). Any of these abnormalities should lead to further testing. It is important to note that the absence of any of these abnormalities fails to rule out PAD (i.e. an ABI>0.9) in high-risk populations [57].

The ABI is a widely accepted tool for the diagnosis of PAD. The American Diabetes Association (ADA) recommends screening with ABI in all diabetic patients >50 yrs, to be repeated every 5 years if normal [53]. This test is simple, reproducible and non-invasive, and shows excellent correlation with angiographic findings [53, 58]. The main drawback of the ABI is the possible presence of medial artery calcification. Medial artery calcification is related to autonomous neuropathy and renal failure/proteinuria [59-61], and can be identified on plain foot and leg X-ray films. It can render arteries incompressible and thus lead to high ABI values (≥1.3) [56]. A high ABI should lead to additional vascular testing such as toe/brachial index or transcutaneous oxygen tension (TcPO2) measurements. Unidentified medial artery calcification can potentially lead to falsely normal (0.9-1.3) ABI values in the presence of PAD.

2.3.3. Prevention of PAD

PAD is a largely preventable disorder. As already mentioned, poor glycaemic control and hypertension are important risk factors, and optimisation of diabetes care and antihypertensive treatment can be expected to prevent or delay PAD [51, 62]. As shown in the UKPDS observational study, the risk of PAD is increased in smokers, but not in ex-smokers… to quit smoking really helps! [51]. Statin treatment was also shown to prevent PAD in the Scandinavian Simvastatin Survival Study (4S) [62]. Existing, diagnosed PAD also provides an incentive to optimise cardiovascular risk factor management, in particular antiaggregant therapy with aspirin [63-64]. The CAPRIE (Clopidogrel versus Aspirin in Patients at Risk of Ischemic Events) study comparing clopidogrel to aspirin in the prevention of cardiovascular events, has even found a clear superiority of clopidogrel only in the sub-group presenting with PAD [65].
2.4. Triggering events

Studies on causal pathways to ulceration have emphasized that ulceration is a complex multistep process [66]. In a patient presenting with risk factors (such as neuropathy, foot deformities, PAD or with a history of previous ulcer or amputation), ulceration still requires a triggering event (also referred to as “pivotal event” [67]), mostly unnoticed trauma. However, a similar trauma would not have caused ulceration in the absence of these risk factors. Increasing risk awareness and promoting the avoidance of triggering events in high risk patients represent a major opportunity for the prevention of foot ulcers [68].

Trauma from inadequate footwear is an important trigger for skin lesions. In various diabetic clinical and research populations, 39 to 76% of LEA were initiated by ill-fitting footwear [15, 59, 69-70]. The proportion of elderly people on a general rehabilitation ward wearing incorrectly sized or ill-fitting shoes was 72% [71]. Other important triggering events should be considered, such as direct trauma, self-care (“bathroom surgery”), paronychia and decubitus [67]. In patients using wheelchairs, direct trauma or heel decubitus are also encountered.

The effectiveness of therapeutic footwear in the prevention of foot ulceration has been hotly debated. A much-noticed study by Reiber et al. [67] providing two different types of shoes to patients with a previous foot ulcer found no evidence of reduced reulceration rate. However, these patients were at low risk (as shown by the low incidence of reulceration in the control group) and included many patients without sensation loss or foot deformity. In addition this study reemphasized the high proportion of ulcer triggered by shoe-unrelated trauma [67]. Several smaller, clinic-based studies providing therapeutic footwear to high risk patients (with prior ulceration) were found to be highly effective in reducing the rate of reulceration [47, 72-74]. These studies were usually conducted in the context of multi-factorial interventions, including patient education and regular follow-up. It seems obvious that beyond appropriate shoes, attention should be paid to the prevention of other possible trauma. As detailed below, compliance with therapeutic footwear is likely a major issue. Elderly patients often spend much time at home, where trauma on bare feet is a significant risk. It seems reasonable to conclude that providing therapeutic footwear is effective if it is not an isolated intervention.

Podiatric follow-up attending to toenail care and callus removal are also an important part of ulcer prevention. Plantar callus formation may be less frequent with increasing age, possibly as a consequence of reduced weight-bearing physical activity [75-76], but callus at other locations or poor toenail care remain important potential triggering events. Podiatric care is usually advocated in the context of multiple intervention programs [72, 77]. To our knowledge its effectiveness has never been directly demonstrated, and in many health systems it faces significant reimbursement difficulties. Whenever feasible, podiatric care is a useful component of preventive care, also providing an opportunity to improve footwear.

It seems important to improve the awareness among physicians of the potential for the prevention of diabetic foot disease. In a large population of individuals with type 2 diabetes, more than 50% reported that they had not had their feet examined by their physician and 28% referred that they had not received foot education [68]. Medical teams should also keep aware of the risk of ulceration during acute care: decubitus ulcers in bedridden patients or during surgery can be prevented by adequate offloading. Greater physician awareness has a great potential for improving patient awareness and self-care.

3. Classification and treatment of diabetic foot ulcers

A detailed discussion of the care of diabetic foot ulcers is beyond the scope of this brief review. This topic has recently been extensively reviewed [26]. We will restrict our discussion to those issues where the specificities of care in elderly patients seem important.

3.1. Wound classification

An efficient and realistic care program can be determined only after adequate classification of the foot ulcer. Many classification systems are in current use. The Texas classification has the advantage of taking into account not only ulcer depth but also the presence of infection or PAD, which significantly worsen the outcome, but fails to consider foot deformities [16]. It should be emphasized that all available classifications look at the feet only, a problem that is particularly obvious in elderly patients. A meaningful prognosis and program of care can only be established after the wound classification is completed by a comprehensive geriatric assessment, taking into account the patient’s overall co-morbidities, prognosis and functional capacities.

3.2. Pressure relief (off-loading)

Pressure relief is probably the single most important, but also most problematic intervention in the care of foot ulcers. Many pressure relief devices are available. Half-shoes, removable cast walkers (RCW), and total contact casts (TCCs) are designed to relieve forefoot pressure [78]. TCCs, which provide optimal forefoot pressure relief with a non-removable device, afford excellent wound closure rates. An important feature of TCCs is that they are non-removable, thus solving the issue of non-compliance. In fact, similar wound closure rates are obtained with “sealed” RCW as with TCCs [79]. However, even when readily available these devices are often difficult to use in elderly patients. Although few data are available, it is our clinical impression that elderly patients present more frequently
with heel, toe and lateral foot ulcers, and more rarely with plantar ulcers (for which the off-loading devices are designed). TCCs, half-shoes and many other devices cannot be safely used in patients with impaired gait or balance. The use of crutches would obviously provide total pressure relief, but few patients have the required balance and upper body strength.

It seems important to implement off-loading on an individual basis, after enquiring about the patients’ habits and living conditions at home. Avoidance of tight-fitting shoes, elastic insoles and padded, low friction socks are all useful in reducing foot sole pressure [80-82]. Footwear with elastic insoles has been shown to reduce the rate of ulcer recurrence and likely also improves ulcer healing [74]. The efficacy of these interventions can likely be vastly increased by careful attention to patient compliance. As mentioned, most patients, especially those staying most often at home, may not wear their footwear consistently. One study on the compliance with RCW showed that patients took less than half of their daily steps wearing their device [83]. In practice, patients should be asked consistently about all the footwear they use, including slippers; walking barefoot or with socks only should be discussed and discouraged. The consistent use of prescribed, protective footwear can also help to prevent new foot injuries in the home setting. If compatible with the home’s architecture and the patient’s functional status, wheelchairs can be very effective.

Occasionally, bed rest in hospital is the only effective option, mostly as a way to ensure patient compliance and/or in the setting of co-morbidities or social isolation. In that case, the importance of pressure off-loading should be kept in mind in the case of heel ulcers, or to avoid new heel ulcers. Several devices are available to avoid heel contact with the mattress. Whether reduction in physical activity (including bed-rest) should be recommended to improve off-loading in the treatment of foot ulcers is debatable. As already mentioned, recent data suggest quite unexpectedly that among patients with former ulcers, those who suffer ulcer recurrence have lower physical activity, suggesting that the ulcer recurrence and maybe healing is more related to foot skin frailty than to “excessive” walking; in that context weight-bearing activity has even been suggested to promote the formation of higher quality plantar skin [75-76]. Prescribed bed rest is complicated by the loss of skeletal muscle mass and strength, a possibly important problem in elderly patients already at high risk of sarcopenia [84-85]. Hospital admission per se or bed rest have also been associated with functional decline [86-88]. In practice, the benefits of off-loading by prolonged bed rest, whether at home or in the hospital, must be balanced with the detrimental effects of bed rest on the general health status.

A promising approach to off-loading is based on electronic devices promoting a feed-back signal to the patient with loss of pain sensation and high plantar pressure and/or significant shear forces [89-90]. Validation studies are necessary to confirm the usefulness of this behaviorist approach in elderly diabetic patients.

3.3. Debridement and wound dressings

Debridement (incision) is another key element in the care of foot ulcers, as it allows removal of proinflammatory products and reduction of the bacterial load. Debridement is poorly standardized and local practices seem to vary considerably. It should involve removal of non-viable, undermined tissue [78]. In a comparison across institutions, the wound closure rate was shown to improve with higher frequency of debridement [91]. Debridement should be carried out with extreme caution in ischemic wounds. Debridement with maggot (larval) therapy is a promising option in the care even of ischemic wounds, but is not widely available [92-93].

Many types of dressing have been tested for their efficacy in the treatment of foot ulcers, usually in comparison with conventional moist saline dressings. These include sophisticated (and often expensive) products such as Promogran®, recombinant PDGF (Platelet Derived Growth Factor), and bio-engineered human skin equivalents [94-96]. Although some dressings have shown greater patient and caregiver satisfaction, their benefits in terms of wound closure have been minor or absent. In any case the healing rates were lower than with TCCs (which are incompatible with the use of sophisticated dressings). These observations again emphasize the crucial role of pressure relief in wound healing, and the relatively minor role of the choice among the many available moist wound dressings.

A recent study has shown successful use of negative pressure wound therapy (VAC® system) in the care of post-amputation, non-infected, non-ischemic forefoot wounds [97]. We believe this can be an interesting option in many foot ulcers in elderly, bedridden patients where shortening of the healing time is particularly important. The study was not performed in an elderly population and the issue clearly deserves further studies.

3.4. Wound infection and osteomyelitis

The diagnosis and treatment of wound infection and osteomyelitis are essential components of foot ulcer care. However, these issues have been reviewed elsewhere [26] and in the absence of outstanding specificities in the elderly patients, will not be discussed here.

3.5. PAD and arterial reconstruction

Tissue ischemia impairs the healing process and predicts poor ulcer closure or amputation. The presence of PAD should therefore be determined in all patients present with a deep foot ulcer that hasn’t healed after approx. 4 weeks. Ankle or toe pressure are good predictors of ulcer healing. Cut-off values of <50 and <30 mmHg respectively have
been proposed for the prediction of non-healing or amputation [98-100]. TcPO2 measured at the foot dorsum, used with a cut-off of >20-30 mmHg, is a predictor of ulcer healing or successful amputation [99, 101]. Toe pressure is particularly useful in patients with incompressible tibial posterior or dorsalis pedis arteries. TcPO2 has been suggested to provide prognostic information additional to ankle or toe pressure [99] but has its own limitations, such as the presence of edema. Given the pitfalls of each test, it seems reasonable to use them in combination whenever available.

In the presence of PAD, the indications for angioplasties or revascularization surgery in elderly patients are debatable. An aggressive surgical approach to non-healing ulcers, combining distal bypass surgery and surgical bone removal has been advocated [102]. Actually many surgical procedures have been shown to be effective. The results of bypass surgery are quite good: according to the American College of Cardiology/American Heart Association (ACC/AHA) consensus [64], the expected patency rate for aorto-iliac or aorto-femoral grafts is >85% and for femoro-popliteal bypass (using autologous vein grafts) >65% at 5 years. Diabetic patients often present with infra-popliteal arterial disease [103], which may require more distal surgery. The patency rate of bypass surgery is generally lower below than above the knee. However, even for dorsalis pedis bypass a patency rate of 57% at 5 years has been reported [104]. Balloon angioplasty can also be considered. The 3-year patency rate for femoro-popliteal angioplasty is 40-70%, lower than for bypass surgery. However, since it is less invasive and can be repeated, it is an important option, particularly in elderly patients [105].

Given all these available options, it may sound reasonable to suggest that diagnosis of PAD should be followed by arteriography, and whenever possible surgical revascularization or angioplasty. Short of ulcer healing, revascularization can help gain a more distal amputation level or permit effective bone removal surgery [102]. However, particularly in elderly patients, the indications for revascularization should be considered on an individual basis, with caution and appropriate restraint. The real-world effectiveness of surgery may vary widely depending on the expertise of the local surgical teams. The age, prognosis and co-morbidities of the patient must also be taken into account. The hazards of arteriography, including radiocontrast media-induced acute renal failure and cholesterol emboli are not negligible (although the risk of renal failure can be minimized by using Magnetic Resonance Angiography). The potential hazards of multiple surgical interventions and/or prolonged hospital stays on elderly patients’ functional status also deserve consideration. It may be reasonable to perform even high-risk surgery in cases of severe ischemic pain or foot gangrene. However, we believe that in frail patients, many “non-healing” ulcers should be treated in a less aggressive manner. Although very few data are available, its appears that even in cases of severe PAD, a significant proportion foot ulcers heal or at least don’t worsen [15-16, 98]. Localized gan-

grene at the end of the toes or the heels is not necessarily due to severe ischemia. Necrotic tissue with viable borders can be left to separate with minimal intervention, resulting in so-called “auto-amputation”. Although we are not aware of any detailed studies, it seems that the risk of bacteremia or sepsis is quite low. The main risk of a conservative approach is local infection, leading to worsening of the wound or emergency amputation. In many instances this risk seems acceptable provided that adequate wound surveillance, debridement and dressing changes are provided.

In summary, PAD is the main cause of poor ulcer healing or amputation. Whenever possible, arterial reconstruction should be attempted prior to amputation. However, in patients unable to tolerate repeated surgery, dedicated and patient wound care is the only remaining and not-so-desperate option.

4. Conclusions

Diabetic foot disease is common in the elderly population and contributes to amputations and other disabilities, physical and psychological suffering and high treatment costs. The incidence of foot ulcers and amputations is likely underestimated by current epidemiological data. Foot ulceration is a multifactorial process in which neuropathy plays an essential role. The pathophysiology of ulceration is not fundamentally different in old than in young patients. However, while “classical” plantar ulcers associated with focal hyperkeratosis may become less frequent, the role of foot deformities, reduced soft tissue thickness and PAD increases.

The prevalence of neuropathy, foot deformities and PAD, as well as the risk of amputation all increase with age, even in non-diabetic patients. The principles of prevention and management of diabetic foot disease may also apply to large segments of the elderly non-diabetic population.

The best prevention of foot ulcers is the prevention of its risk factors. Neuropathy and PAD can be avoided or delayed by life-long attention to glycaemic control, treatment of hypertension and dyslipidemia and smoking cessation. Even when neuropathy occurs, ulceration can be prevented by the identification of high-risk patients and avoidance of triggering events such as ill-fitted shoe-wear and other causes of trauma. The treatment of foot ulcers relies on pressure relief (off-loading), wound incision (debridement), and the management of infection and ischemia. All these interventions remain just as important in elderly patients. However, the management of foot disease in the elderly requires (even more than in the young) careful attention to co-morbidities and to the functional status. An individualized approach to pressure relief and trauma avoidance, taking into detailed account the patient’s living conditions at home and patient, repeated instructions are important. Many interventions such as sophisticated pressure relief devices or orthopedic and vascular surgery are limited by the patients’ functional status or prognosis. In these cases dedicated care is the best
approach, even if it tests both the patient’s and the physician’s patience. While the general principles of prevention and care are clear, it is important to underline that in elderly patients, individual situations deserve individualized solutions.

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