Use of the SINBAD Classification System and Score in Comparing Outcome of Foot Ulcer Management on Three Continents

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OBJECTIVE — To compare populations with and outcomes of diabetic foot ulcers managed in the U.K., Germany, Tanzania, and Pakistan and to explore the use of a new score of ulcer type in comparing outcomes among different countries.

RESEARCH DESIGN AND METHODS — Data from a series of 449 patients with diabetic foot ulcers managed in the U.K. were used to evaluate the new simplified system of classification and to derive an aggregate score. The use of the score was then explored using data from series managed in Germany ($n = 239$), Tanzania ($n = 479$), and Pakistan ($n = 173$).

RESULTS — A highly significant difference was found in time to healing between ulcers of increasing score in the U.K. series (Kruskal-Wallis test; $P = 0$). When data from all centers were examined, a step-up in days to healing was noted for those with scores of ≥3 (out of 6). Examination of baseline variables contributing to outcome revealed the following differences among centers: ischemia, ulcer area, and depth contributing to outcome in the U.K.; ischemia, area, depth, and infection in Germany; depth, infection, and neuropathy in Tanzania; and depth alone in Pakistan.

CONCLUSIONS — Any system of classification designed for general implementation must encompass all the variables that contribute to outcome in different communities. Adoption of a simple score based on these variables, the Site, Ischemia, Neuropathy, Bacterial Infection, and Depth (SINBAD) score, may prove useful in predicting ulcer outcome and enabling comparison among different centers.

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There is no widely accepted system of classification for diabetic foot ulcers (1–3). The lack of consensus is explained partly by their varying presentation and partly because the specification of a classification depends on its intended use (3). A classification for use in clinical care can be relatively flexible and descriptive, whereas one used for audit must be more structured but simple enough for use in larger populations. This differs from one used for prospective research, which should be selective and exclusive (4). While the University of Texas system (5) has been widely adopted, we have argued that the Size (Area, Depth), Sepsis Arteriopathy, and Denervation (S(AD)SAD) system (6) might be better suited for audit because of its greater specificity (3) and especially because rather different factors contribute to outcome in countries depending on whether they are more (7–11) or less (12–15) industrialized. The inclusion of more criteria makes the system more complicated, however, and harder to apply in routine practice, especially in resource-poor communities where the burden of patient numbers can be enormous (15). The aim of the present study, therefore, was to create a simplified version of the S(AD)SAD classification in which the original five elements (area, depth, infection, ischemia, and neuropathy) were retained while the structure was simplified by reducing the number of subgroups to two. The modified version, the Site, Ischemia, Neuropathy, Bacterial Infection, and Depth (SINBAD) classification, also includes ulcer site because newer data suggest that ulcer site may also be an important determinant of outcome (8,10) (Table 1). The components of the classification can be summed to produce a score between 0 and 6.

RESEARCH DESIGN AND METHODS

— The contribution to outcome made by demographic features and baseline ulcer characteristics has been reported in a consecutive cohort of 449 patients referred to a specialist clinic in Nottingham, U.K., over 4 years (8). Each lesion was classified using the S(AD)SAD system at the time of first attendance and recategorized retrospectively for the purposes of the present study using the SINBAD system (Table 1). The data to define the site were available from the clinic database. In the SINBAD system, these six elements were graded as follows: *1*) ulcer site (forefoot [distal to tarso-metatarsal joint], 0, and midfoot/hindfoot, 1); *2*) ischemia (blood flow relatively intact [at least one pulse palpable on the affected foot], 0, and evidence of ischemia [neither pulse palpable with signs of reduced tissue perfusion, with or without gangrene], 1); *3*) neuropathy, defined as being absent, 0, or present, 1, on the basis of routine examination using either Neurotips (Owen Mumford) or 10-g nylon monofilaments; *4*) bacterial infec-

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Abbreviations: S(AD)SAD, Size (Area, Depth), Sepsis, Arteriopathy, and Denervation; SINBAD, Site, Ischemia, Neuropathy, Bacterial Infection, Area, and Depth.

Table 1—*The SINBAD system for classifying and scoring foot ulcers*

Category	Definition	SINBAD score	Equivalent S(AD)SAD categories
Site	Forefoot	0	—
	Midfoot and hindfoot	1	—
Ischemia	Pedal blood flow intact: at least one pulse palpable	0	0–1
	Clinical evidence of reduced pedal blood flow	1	2–3
Neuropathy	Protective sensation intact	0	0–1
	Protective sensation lost	1	2–3
Bacterial infection	None	0	0–1
	Present	1	2–3
Area	Ulcer $<1cm^2$	0	0–1
	Ulcer $\geq 1cm^2$	1	2–3
Depth	Ulcer confined to skin and subcutaneous tissue	0	0–1
	Ulcer reaching muscle, tendon or deeper	1	2–3
Total possible score		6	—

tion (using clinical signs of infection of either soft tissue or bone proposed by the Infectious Diseases Society of America and the International Working Group on the Diabetic Foot) (16,17), graded as absent, 0, or present, 1; 5) area (the two maximum dimensions at right angles multiplied [≤ 1 cm^2, 0, and >1 cm^2, 1]; and 6) depth (superficial, 0, and deep [reaching to tendon, periosteum, joint capsule, or bone], 1) (Table 1). In addition, the individual grades were summed, creating a SINBAD score range of 0–6. We sought to identify the contribution made by each of the six elements to outcome (healed vs. nonhealed) by using χ^2 and logistic regression. An association was also sought between SINBAD score and median time to healing. These analyses were repeated using data collected prospectively in consecutive series of patients managed in specialist clinics in Dar es Salaam (Tanzania), Karachi (Pakistan), and Soest (Germany). Foot care services in Pakistan are private, whereas those in the other countries are free at the point of delivery and paid for by either central government or personal insurance. The data from the patients managed in Dar es Salaam have previously been used to compare four different systems of classification (Wagner, University of Texas, S(AD)SAD, and PEDIS [Perfusion, Extent, Depth, Infection, and Sensation]) (18). The data from Germany have been compared with those of separate populations managed in Tanzania and India (19). Univariate analysis was undertaken seeking differences between baseline variables and outcome (healed vs. nonhealed, including amputation and death) using Pearson's χ^2 or Fisher's exact tests. Variables with a significance of $P < 0.05$ were entered for multivariate analysis by logistic regression. It has previously been established by the Caldicott Guardian in Nottingham that ethical approval is not required to analyze anonymous data collected during the course of routine management.

Table 2—*Baseline demographic details and outcomes in the four centers*

	Nottingham	Soest	Dar es Salaam	Karachi
n	449	239	479	173
% type 2 (if known)	86.0	89.5	98.0	98.8
Age (years)	66.7 ± 13.2	69.4 ± 10.6	54.5 ± 11.3	53.2 ± 12.2
Men	63.7	59.0	66.8	66.5
Eventual healing	65.7	72.0	48.0	59.0
Persisting unhealed	11.6	0	14.4	0
Resolved by amputation	8.0	19.2	12.1	8.1
Unhealed at time of death	10.9	8.8	3.8	0.6
Outcome unknown	3.8	0	21.7	32.4
Time to outcome (days)	91 (6–1,344)	70 (1–967)	30 (0–973)	60 (1–1,088)

Data are means ± SD, %, and median (range) unless otherwise indicated.

Table 3—*Prevalence of ulcers of different SINBAD score in the four centers*

SINBAD score	Nottingham*	Soest†	Dar es Salaam‡	Karachi§
0	2.9	2.9	1.0	0
1	18.9	13.0	8.6	0
2	36.7	26.4	23.4	2.3
3	18.2	16.3	17.7	31.8
4	15.1	18.8	33.0	49.7
5	6.3	19.7	15.9	15.6
6	1.8	2.9	0.4	0.6

Data are %. *n = 449; †n = 239; ‡n = 479; §n = 173.

RESULTS — Data from the 449 consecutive cases managed in Nottingham were used to analyze outcomes according to the simplified baseline categories and to explore the significance of the aggregate SINBAD score. The median time to healing in the 323 cases that healed without amputation was determined for ulcers with different SINBAD scores, and a highly significant difference between groups was found (χ^2 37.324, Kruskal-Wallis test; $P = 0$). Data from the other three centers were then classified according to the new system.

Table 2 summarizes baseline demographic details and outcomes of the ulcers managed at the four centers. Outcomes were determined at a fixed date in each center; median time to outcome varied from 30 to 91 days with maximum durations of follow-up ranging from 973 to 1,344 days. The prevalence of ulcers of different SINBAD score in the four centers is shown in Table 3 and the median time to healing (of ulcers that healed without amputation) in Table 4.

Univariate analysis revealed signifi-

Table 4—*Time to healing (days) per SINBAD score for ulcers that healed in each center*

SINBAD score	Nottingham*	Soest†	Dar es Salaam‡	Karachi§
0	77 (7–243)	19 (2–37)	36 (25–40)	—
1	77 (7–1029)	39 (7–91)	24 (5–47)	—
2	70 (7–1344)	56 (9–145)	29 (4–519)	28 (12–44)
3	126 (14–1330)	78 (19–375)	42 (7–404)	57 (7–384)
4	140 (21–693)	131 (22–497)	61 (8–574)	92 (7–1088)
5	113 (42–427)	273 (110–461)	68 (7–226)	101 (18–387)
6	577 (384–770)	269 (103–421)	—	—

Data are median (range). *n = 449; †n = 239; ‡n = 479; §n = 173.

cant differences between the baseline categories associated with outcome (healing vs. nonhealing) in the four centers (Table 5). Ulcer depth was the only variable associated with healing in the series from Karachi, although trends to differences were observed for site (Fisher's exact test; $P = 0.069$) and for ischemia (Fisher's exact test; $P = 0.090$). The results of multivariate analysis are shown in Table 6.

CONCLUSIONS — This study reveals that different baseline ulcer characteristics are associated with outcome in different countries. It also shows that these characteristics can be expressed in an aggregate SINBAD score, with a score of three or more being associated with a step-up in time to healing and in eventual failure to heal. The SINBAD score may therefore represent a system for defining ulcer type that could be applied worldwide. A strength of the study is that it employs data collected prospectively in consecutive series of patients. A limitation lies in the outcome data being based on variable duration of follow-up, weakening to some extent the descriptive analysis of eventual outcome (healing, nonhealing, amputation, and death).

The results confirm the marked differences in the nature of foot lesions managed in different countries and in patient age, as previously reported (19). Those in less industrialized countries are ~15 years younger and because there is also a lower prevalence of peripheral arterial disease, foot ulcers in developing countries tend to be caused by trauma from inappropriate or nonexistent footwear and are frequently complicated by infection. When access to free health care is not available (as in Pakistan) or delayed because of initial reliance on traditional healers (as in Tanzania), patients may present late and with more severe infection. It has been estimated that the management of a single ulcer costs on average between 0.3 and 5.5 times the average total monthly expenditure for a household in Pakistan (A.B., S.M.A., A. Fareed, S. Mujahid Humail, M. Yakoob Ahmedani, A. Fawwad, Z. Miyan, unpublished data). It is probably for such reasons that in the series from these two countries, relatively uncomplicated lesions (those with SINBAD scores of 0–2, Table 3) were underrepresented, whereas the number lost to follow-up was high.

The differences in patient population and ulcer type emphasize the need for using appropriate systems of classification to compare ulcer outcomes among centers. Such systems must encompass all the variables that may be associated with outcome, and our findings reveal that these vary considerably, with only depth being common to all centers on univariate analysis (Table 5). By using an aggregate scoring system, however, it is possible to obtain a measure of ulcer type independent of the specific factors of which it is comprised and enables such comparisons to be made. Inspection of Table 4 reveals a clear step-up in time to healing between SINBAD scores of 2 and 3 in each of the four centers, suggesting that those with ulcers of grade 3 or greater are at particular risk.

Interesting differences were also observed between outcomes in the studied populations in the U.K. and Germany. The main difference between the two lies in the strong association that exists in Germany between infection and outcome; the association was only weak in the U.K. and lost in multivariate analysis. The incidence of amputation (major and minor combined) was also much higher in the German cohort (19.2 vs. 8.0%), although it is important to note that the two series were not concurrent, dating from 1998 to 1999 and 2000 to 2003, respectively, and the incidence of amputation for all new ulcers in Soest has since fallen by 60% (S.M., unpublished data). From 1998 to 1999, however, it is possible that it was more common in Germany to manage osteomyelitis by early elective excision of bone, whereas most centers in the U.K. reserve amputation for those with either overwhelming infection or who fail to respond to initial antibiotic treatment (19,20). In this respect, the findings in Germany resembled those in North America, where a similarly close association has been shown between outcome (incidence of amputation) and infection at baseline (5) and where early surgery is more common practice. Conversely, some 11.6% of the population managed in the U.K. had persisting disease at the time of assessment in the present series versus 0% in Germany. Moreover, the time to healing was longer in the U.K. than in any of the other three centers for ulcers of all grades and, although this

Table 5—*Significant associations between baseline variables and outcome (healing vs. persisting nonhealing plus unhealed at death plus amputation) in the four centers*

SINBAD baseline variable	Nottingham	*P*	Soest	*P*	Dar es Salaam	*P*	Karachi	*P*
Site	—	—	—	—	4.131	0.027	—	—
Ischemia	22.302	0	28.615	0	—	—	—	—
Neuropathy	—	—	—	—	12.508	0	—	—
Bacterial infection	5.082	0.019	44.354	0	41.633	0	—	—
Area	24.535	0	54.539	0	—	—	—	—
Depth	27.154	0	64.137	0	30.753	0	11.496	0

Data are χ^2.

Table 6—*Significant independent associations (logistic regression) between baseline variables and outcome (healing vs. persisting nonhealing plus unhealed at death plus amputation) in the four centers*

SINBAD baseline	Nottingham	Soest	Dar es Salaam	Karachi*
Site		—	0.340–0.894 (0.016)	—
Ischemia	2.046–7.484 (0)	2.695–14.228 (0)	—	—
Neuropathy		—	1.466–9.345 (0.006)	—
Bacterial infection		1.963–20.325 (0.002)	1.596–7.781 (0.002)	—
Area	1.436–4.461 (0.001)	—	—	—
Depth	1.322–5.009 (0.005)	3.950–49.970 (0)	—	—

Data are 95% CI (*P*). *The Karachi data were not assessed because only one variable achieved significance on univariate analysis.

could reflect less effective care, it could also result indirectly from lower incidence of amputation and an attempt to achieve healing without surgery in a greater proportion of the population. Detection of differences such as these highlights the value of comparative audit and pinpoints the need for formal assessment of the advantages and disadvantages of different strategies of care.

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