Martorell Hypertensive Ischemic Leg Ulcer

A Model of Ischemic Subcutaneous Arteriolosclerosis

Jürg Hafner, MD; Stephan Nobbe, MD; Hugo Partsch, MD; Severin Läuchli, MD; Dieter Mayer, MD; Beatrice Amann-Vesti, MD; Ruedi Speich, MD; Christoph Schmid, MD; Günter Burg, MD; Lars E. French, MD

Objectives: To better define the diagnosis and treatment of Martorell hypertensive ischemic leg ulcer (HYTILU) and to compare Martorell HYTILU with calciphylaxis (calcific uremic arteriolopathy) and nonuremic forms of calciphylaxis.

Design: Retrospective study from 1999 through 2007.

Setting: Department of Dermatology, University Hospital of Zurich, Zurich, Switzerland.

Participants: Of 330 patients with leg ulcers, 31 had a clinical diagnosis of Martorell HYTILU confirmed by dermatopathologic examination.

Main Outcome Measures: Clinical features, suspected diagnosis at initial presentation, cardiovascular risk factors, findings from vascular examination and histologic analysis, specific medical and surgical management, and outcome.

Results: Of the 31 patients, all presented with 1 or multiple painful necrotic skin ulcers on the laterodorsal part of the leg, with bilateral involvement in 16 of 31 cases (52%), and 16 were referred with suspected pyoderma gangrenosum. All patients had arterial hypertension, and 18 (58%) had diabetes. All patients had subcutaneous stenotic arteriolosclerosis on histologic analysis, with medial calcification in 22 of 31 of cases (71%). Martorell HYTILU, calciphylaxis, and nonuremic forms of calciphylaxis shared identical histologic features. Of the 31 patients, 29 (94%) were successfully treated with surgical debridement and split-thickness skin grafting. Three patients (9%) died of sepsis, 2 of whom were undergoing immunosuppressive treatment for wrongly diagnosed pyoderma gangrenosum.

Conclusions: Ischemic subcutaneous arteriolosclerosis is the hallmark of Martorell HYTILU, calciphylaxis, and the nonuremic forms of calciphylaxis. All patients are hypertensive and approximately 60% are diabetic. Martorell HYTILU can easily be confused with pyoderma gangrenosum, which can be detrimental, since the 2 diseases require a completely different treatment strategy.

Arch Dermatol. 2010;146(9):961-968

Martorell hypertensive ischemic leg ulcer (HYTILU) was originally described by Fernandes Martorell in 1945 in Barcelona, Spain. Martorell described 4 obese, hypertensive female patients with painful leg ulcers on the lateral aspect of their legs. One year later, Hines and Farber and coworkers reported an association of such leg ulcers with the histologic presence of hypertrophic stenotic subcutaneous arterioles and coined the term hypertensive-ischemic ulcer. In 1966, Schnier et al reported a series of 40 patients with HYTILU, pointing out the very characteristic location of the principal lesion on the laterodorsal lower leg. In 1995, Lazareth and Priollet described the benefit of skin grafting for the treatment of l’angiodermite nécrotique, the term used by the French to describe HYTILU, which was confirmed by Henderson et al in a survey on 16 patients. The literature on HYTILU is otherwise scarce, and to our knowledge, studies analyzing the clinical and dermatopathologic characteristics and possible therapies on a significant number of patients do not exist.

For editorial comment
see page 1026

At our department, Martorell HYTILU has become one of the leading causes of chronic leg ulceration in the past 10 years. Martorell HYTILU shares striking clinical and histopathological similarities with calciphylaxis (calcific uremic arteriolopathy) and eutrophication in morbid obesity. The latter has recently been referred to as “calciphylaxis with normal renal and parathyroid function” or “calciphylaxis from nonuremic causes.” This study of a large series of patients with Martorell HYTILU defines common pathophysiological hallmarks of 4 entities that are linked to ischemic subcutaneous arteriolosclerosis (Table 1) and outlines treatment protocols.
Confusing Martorell HYTILU with pyoderma gangrenosum (PG) can be detrimental to the patient. Necrosectomy (debridement of necrotic tissue), with skin grafting and antibiotic therapy as required, is probably the key to timely and effective treatment of Martorell HYTILU, but an erroneous diagnosis of PG virtually excludes surgical measures from the therapeutic decision. As noted by Weenig et al, one of the risks of misdiagnosing an inflammatory type of skin ulcer as PG is that the systemic immunosuppression used to treat PG exposes the patients to the risk of sepsis. Therefore, this study also aims to clarify the description of Martorell HYTILU and PG to avoid misdiagnosis and therapeutic decisions.

METHODS

Medical records of 330 patients with leg ulcers who visited our outpatient or inpatient department between 1999 and 2007 were screened for the diagnosis of Martorell HYTILU (Figure 1). We identified 31 patients with both clinically and histologically proven HYTILU, whose files, clinical photodocumentation, and skin biopsy specimens were re-examined. During the same period, 2 patients with calciphylaxis (calcific uremic arteriolopathy) and 1 patient with eutrophiciation in morbid obesity (calciphylaxis with normal renal and parathyroid function) were treated in the department, and their records were also re-evaluated in the present study. The study was submitted to and approved by the local ethics committee.

DIAGNOSIS

Clinical characteristics that were studied included age, sex, wound location, documentation of pain, diagnosis at the time of referral (specifically PG), medication at the time of referral (specifically antihypertensive or antidiabetic drugs and immunosuppression for supposed PG), and cardiovascular risk factors.

Skin biopsy specimens derived from the wound border were re-examined with a focus on the presence of subcutaneous stenotic arteriolosclerosis with or without medial calcification. Vascular assessment comprised a thorough clinical examination, measurement of the ankle-brachial pressure index (ABPI), segmental oscillography in case of medial calcinosis, and, in the presence of pathologic findings, imaging via fine-needle angiography.

To identify patients with end-stage renal disease (ESRD) or kidney transplant recipients and hence patients with potential calciphylaxis (calcific uremic arteriolopathy) or with a primary hyperparathyroidism, the records of all 31 included patients were checked for renal function and parathyroid hormone and calcium phosphate product levels. The latter two were prospectively determined in the 16 patients who were included in the study between 2005 and 2007.

TREATMENT

Our standardized treatment protocol for the management of Martorell HYTILU is summarized in Figure 2. Basically, the diagnosis is based on the typical history and clinical presentation and confirmed by obtaining a large wedge-shaped biopsy specimen (approximately 5.0 × 0.8 cm, reaching the fascia) starting from healthy skin at the wound border and extending into the necrotic area. Immunosuppression for presumptive PG was stopped and antibiotic treatment initiated as required by the general or local condition. In addition, necrosectomy using adequate—usually tumescent—local anesthesia was undertaken, local negative pressure treatment was started if the wound bed still contained subvital tissue, and split-thickness skin grafting (0.2-mm-thick, meshed graft) was then performed as soon as possible.

RESULTS

CLINICAL ASSESSMENT

Of the 31 patients included, 19 (61%) were female, and the mean age of patients was 72 years (range, 61-91 years). The main clinical observation at presentation was skin necrosis with a polycyclic violaceous-black border localized on the laterodorsal part of the leg (Figure 3), with a surface area ranging from 2 to 242 cm². Skin necrosis involved the entire subcutis down to the fascia. Sixteen patients (52%) had bilateral lower leg necrosis, and the Achilles tendon was the principal wound location in 4 of the 31 of patients (13%) (Figure 4 and Table 2). Pain was typically strong to excruciating. Seven patients (23%) reported a minor trauma to be the initial trigger, whereas the remaining persons reported a spontaneous onset presenting as a violaceous macule or nodule.

All patients had arterial hypertension and were receiving antihypertensive treatment. It was not possible to collect valid data on the history and duration of hypertension because the majority of patients could not recall the year in which hypertension was diagnosed. However, several patients recalled taking antihypertensive medications for more than 20 years. Of the 31 included patients, 18 (58%) had documented type 2 diabetes mellitus (Table 2) and 5 (16%) had a history of cigarette smok-
Of the 25 patients in which lipid levels were recorded, 5 (20%) had elevated serum lipid levels, all of whom were being treated with a statin.

**DIAGNOSIS AT ENTRY**

Of the 31 patients, 16 (52%) had a referral letter stating PG as the suspected diagnosis. Of these 16 patients, 9 (56%) were unresponsive to high-dose systemic immunosuppressive drugs, of whom 8 received treatment with high-dose oral steroids associated with steroid-sparing agents (cyclosporine \( n = 3 \), mycophenolate mofetil \( n = 3 \), and intravenous cyclophosphamide pulses \( n = 2 \)) and 1 received cyclosporine monotherapy.

In another 6 patients (19%), necrotizing cutaneous leukocytoclastic vasculitis was mentioned as the likely diagnosis. Three of these patients were treated with oral steroids, resulting in a total of 12 patients (3 of 31 [39%]) taking immunosuppressive treatment at the time of admission.
HISTOLOGIC CHARACTERISTICS OF SKIN BIOPSY SPECIMENS

Re-examination of the histologic specimens revealed stenotic arteriolosclerosis of the subcutaneous arterioles with an inverse wall to lumen ratio (Figure 5). In 22 of 31 patients (71%), medial calcinosis of the subcutaneous arterioles was found to be an additional characteristic feature (Figure 6B). Of these 22 patients, 14 (61%) with medial calcinosis of the subcutaneous arterioles were diabetic, compared with 18 of all 31 patients (58%).

VASCULAR ASSESSMENT

Fourteen patients (45%) underwent pathologic arterial screening examinations, with medial calcinosis found in 7 (50%). Peripheral arterial disease (>50% stenosis) was confirmed in all 14 patients, and all had lesions that were amenable to percutaneous transluminal angioplasty (Table 2).

Mönckeberg medial calcinosis with incompressible ankle arteries was documented in 11 of 31 cases (35%). Of these 11 patients, 4 (36%) with incompressible ankle arteries had normal oscillography and, therefore, no further investigations, whereas the remaining 7 (64%) underwent angiography.

RENAral FUNCTION, PARATHYROID HORMONE, AND CALCIUM PHOSPHATE PRODUCT

None of the 31 patients with Martorell HYTILU had end-stage chronic renal failure, and none were kidney transplant recipients. Creatinine levels and glomerular filtration rates were normal in 25 of 31 patients (84%) and slightly or moderately impaired (creatinine level, 1.38-1.60 mg/dL [reference range, 0.79-1.19 mg/dL] [to convert to micromoles per liter, multiply by 88.4], and glomerular filtration rate, 34-52 mL/min [reference range, >60 mL/min]) in the remaining 5 (16%).

Among 16 of 31 included patients (52%), parathyroid hormone level was slightly raised (72.1-100.8 pg/mL; reference range, 15-65 pg/mL [to convert to nanograms per liter, multiply by 1.0]) in 6 (38%), of whom 4 had normal renal function and 2 had slightly impaired renal function. In all 16 patients, calcium phosphate product level was normal.

SURGICAL MANAGEMENT

In only 2 of the 31 patients (6%), wounds were healed with conservative treatment. The remaining patients had refractory wounds, or even progressive skin necrosis. All of these...
patients underwent repeated bedside debridement with a disposable ring curette and local anesthesia with EMLA (eutectic mixture of lidocaine and prilocaine) cream, or they underwent sharp necrosectomy in the operating room, usually with tumescent local anesthesia and some required spinal or general anesthesia. Vacuum-assisted negative pressure local wound care was used in 18 patients (58%). Twenty-six patients (85%) received autologous split-thickness skin grafts, of whom 14 (54%) were grafted once; 7 (27%), twice; and 4 (15%), 3 times; and 1 required 6 successive skin grafting procedures.

OUTCOME

By the end of the study, 28 patients (91%) survived and finished the treatment protocol with completely healed wounds. Three patients (9%), all of whom had extensive skin necrosis and 2 of whom had received immunosuppressive therapy for supposed PG, died of sepsis during the active phase of disease.

PAIN MANAGEMENT

All patients reported strong or even excruciating pain at study entry (8-10 on a visual analog scale ranging from 0 to 10). The multistaged medical treatment of pain consisted sequentially of nonsteroidal anti-inflammatory drugs (particularly paracetamol and metamizol), oral or transcutaneous morphine derivatives, tricyclic antidepressive agents, and pregabalin. Patients who did not respond adequately to this regimen within 5 days of onset were referred to the pain control unit of the department of anesthesiology. Skin grafting was by far the single most effective treatment for pain.

COMMENT

On the basis of our case series and review of the medical literature,1-14 we suggest grouping the 4 medical conditions with ischemic subcutaneous arteriolosclerosis as a
common pathophysiologic feature as follows: (1) Martorell HYTILU12-17; (2 and 3) calciphylaxis (calcific uremic arteriolopathy)9-11 in its distal and more severe proximal pattern; and (4) nonuremic calciphylaxis with normal renal and parathyroid function (eutrophication in morbid obesity)12-14 (Table 1). This characteristic arteriolar pathologic feature represents the most peripheral type of arteriosclerosis and seems to be associated with 2 major cardiovascular risk factors often present in patients with Martorell HYTILU, namely long-standing arterial hypertension (in 100% of cases) and diabetes (frequent).

Martorell HYTILU represents the distal pattern of nonuremic calciphylaxis.9,17 Clinically, it is defined by a rapidly progressive, extremely painful eschar on the laterodorsal side of the leg or on the Achilles tendon. Hypertension and histologically proven subcutaneous arteriolosclerosis (showing medial calcinosis in 70% of specimens) are mandatory to make the diagnosis. The mortality in our series was 9%, and immunosuppression may contribute to increase the risk of potentially fatal septicemia.

Eutrophication9 represents the proximal pattern of nonuremic calciphylaxis.12-14 Clinically, it is defined by extensive, rapidly progressive and extremely painful eschar formation on the trunk and proximal extremities, particularly on the proximal and inner portion of the thighs, on the abdomen, and on the breasts.12-14 Both macroscopically and microscopically, eutrophication cannot be distinguished from calciphylaxis of the proximal pattern.9 Case reports of eutrophication describe severe comorbid disease, cancer, and liver cirrhosis.12-14 However, we hypothesize that hypertension and diabetes, which both are regularly found in the context of metabolic syndrome and morbid obesity, may be the driving forces behind calciphylaxis of nonuremic origin. Eutrophication in morbid obesity has been reported to have a mortality of approximately 40% to 60%,12-14 which is comparable to the proximal pattern of calciphylaxis.8,9

In calciphylaxis, an elevated calcium phosphate product level due to secondary hyperparathyroidism has been proposed to be involved in the pathogenesis.8-11 There is good clinical evidence that an elevated calcium phosphate product level increases the risk for cardiovascular events.17-20 By analogy, it would appear probable that it also enhances subcutaneous arteriolosclerosis, but this is not easy to prove. Not all ESRD patients with calciphylaxis exhibit secondary hyperparathyroidism, and parathyroidectomy does not result in clinical improvement in all cases.8

The matrix protein GLA (serum protein H2–Heremans-Schmid glycoprotein/fetuin A) is an effective vascular and tissue protector against calcification.21-24 Future studies on the aforementioned 4 arteriolosclerosis entities will hopefully investigate the role of this protein in disease pathogenesis.8-11 Matrix GLA requires vitamin K–dependent γ-carboxylation to become active, which would support the impression of several authors that the condition of patients with calciphylaxis may deteriorate when they are placed on warfarin therapy.11

Martorell HYTILU is certainly more common than diagnosed and reported in the literature (3 case series in the literature from 1966-1995).8,9 In our series, 50% of patients with Martorell HYTILU were admitted under the referral diagnosis of PG and another 20% under the diagnosis of necrotizing PG. In the literature, there are a considerable number of cases that indeed could represent Martorell HYTILU instead of “leg ulcers in calcinosis cutis”25 or, more commonly, PG.26-29 Moreover, case series reporting the successful surgical management of PG by skin grafts should probably be revisited taking into consideration Martorell HYTILU.20-29

Confusing Martorell HYTILU with entities such as PG or vasculitis can be deleterious,10 since management of the latter 2 diseases is completely different (Table 3). Martorell HYTILU requires anti-infectious treatment and wound surgery, and immunosuppression may expose these patients to an increased risk of septicemia. Martorell HYTILU is an extremely painful eschar that usually occurs on the laterodorsal side of the leg in hypertensive patients aged 60 to 75 years, whereas PG presents as more superficial pustular skin breakdown with a less precise location and 50% of patients have one of the characteristics associated with inflammatory bowel disease. Histologic proof of subcutaneous arteriolosclerosis (Figure 5 and Figure 6A and B) is warranted before making the diagnosis of Martorell HYTILU. Since the results from superficial wound biopsies (“punch” biopsies) can be totally misleading, special attention should be paid to the quality of the biopsy specimen (long, narrow, and deep elliptical biopsy specimen from healthy-looking skin to necrotic skin) (Figure 6).

The wound border in Martorell HYTILU is strikingly inflammatory, so that the existing confusion with PG is to some extent understandable. As with PG, serological parameters of Martorell HYTILU, such as C-reactive protein level and leukocyte counts, can also be markedly elevated during the active phase of disease progression. Martorell HYTILU is initially an atherosclerotic vascular process, and the observed inflammatory response is secondary to the tissue breakdown resulting from local ischemia. The exact cause and pathomechanism of the inflammatory bursts that can be observed during disease progression in Martorell HYTILU are unknown and should be further investigated in future studies.

Duncan and Faris30 compared the skin perfusion of patients with Martorell HYTILU to that of patients with peripheral arterial disease and normal controls, using a scintigraphic method measuring the elimination of intradermally injected technetium Tc 99m under standardized external compression. Patients with Martorell HYTILU had reduced skin perfusion pressure comparable to that in peripheral arterial disease, which was caused by the locally increased vascular resistance instead of a reduced arterial inflow.

Primary (“essential”) arterial hypertension is mainly the result of increased peripheral vascular resistance, which is essentially regulated via the tonus of arterioles.20 Long-standing arteriolar vasoconstriction can lead to a fixed increase in vessel wall thickness and an inverse wall to lumen ratio (“athletic” arterioles as described by Hines and Farber and colleagues20) (Figure 5). The specificity of this finding for the diagnosis of Martorell HYTILU has not been defined. This could be done by a comparative study on cadaveric skin of the laterodorsal leg of a control group of patients.
Some authors believe that arteriole thrombosis is a decisive criterion for making a diagnosis of ischemic arteriolosclerosis, particularly in calciphylaxis. We cannot confirm this hypothesis, since approximately half of the arterioles examined in our specimens were patent. Arteriole thrombosis can occur either primarily or subsequent to tissue breakdown, and the two cannot be distinguished by histopathologic analysis. However, this question could be addressed in future studies using serial sections of the wound border of larger necrosectomy specimens.

The characteristic location of Martorell HYTILU on the laterodorsal side of the leg or the Achilles tendon is not explained to date, but it is most probably related to the anatomy of calf arteries, arterial perforators, and the distribution of subcutaneous arterioles in the leg. Corrosion preparations of amputated limbs of patients with known subcutaneous arteriolosclerosis or postmortem investigations could be helpful in addressing these open questions.

Recent reports promise progress in both conservative and surgical treatment of uremic and nonuremic forms of ischemic arteriolosclerosis. The introduction of the calcimimetic cinacalcet and of the polymeric (and calcium-free) intestinal phosphate binder sevelamer seem to have a beneficial effect on the incidence of macrovascular events in patients with relevant medium-size artery (such as coronary artery) calcification. Cinacalcet has at least been used twice successfully to treat patients with calciphylaxis; however, these promising reports need to be validated in larger series of patients or, ideally, controlled studies. Of even more interest is the intravenous use of sodium thiosulfate, which may have contributed to the apparent increase in frequency of Martorell HYTILU. Martorell HYTILU may thus be understood as late “minor” vascular complication of long-standing arterial hypertension in a population that benefits from intensified medical antihypertensive treatment alone. Future epidemiologic studies may answer the question as to how well optimal antihypertensive control over many years may prevent the occurrence of Martorell HYTILU.

The incidence of Martorell HYTILU may be on the rise owing to better recognition, an actual increase in incidence, or both. We hypothesize that improved antihypertensive treatment helps to extend a patient’s life expectancy and decreases the rate of death due to major cardiovascular complications early in life, specifically myocardial infarction and stroke, which may have contributed to the apparent increase in frequency of Martorell HYTILU. Martorell HYTILU may thus be understood as late “minor” vascular complication of long-standing arterial hypertension in a population that benefits from improved antihypertensive treatment.

Ischemic arteriolosclerosis appears to be a unifying clinicopathological concept for 4 clinical entities that share a common pathophysiologic mechanism, namely (1) distal calciphylaxis (uremic); (2) distal Martorell HYTILU (nonuremic); (3) proximal calciphylaxis (uremic); and (4) eutrophication in morbid obesity or proximal nonuremic calciphylaxis. We suggest that ischemic subcutaneous arteriolosclerosis may be caused by 2 well-established clas-

### Table 3. Martorell HYTILU, Calciphylaxis, Nonuremic Calciphylaxis, and Pyoderma Gangrenosum

<table>
<thead>
<tr>
<th>Feature</th>
<th>Martorell HYTILU</th>
<th>Calciphylaxis</th>
<th>Nonuremic Calciphylaxis</th>
<th>Pyoderma Gangrenosum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>100% By definition</td>
<td>100%</td>
<td>100% Type 2 diabetes very frequent</td>
<td>Possible, not related</td>
</tr>
<tr>
<td>Diabetes</td>
<td>60% Frequency in this series</td>
<td>Diabetic nephropathy</td>
<td>Possible, not related</td>
<td>Possible, not related</td>
</tr>
<tr>
<td>Morbid obesity</td>
<td>Frequent</td>
<td>No</td>
<td>100% By definition</td>
<td>No</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>No</td>
<td>Rarely, not related</td>
<td>Rarely, not related</td>
<td>Rarely, not related</td>
</tr>
<tr>
<td>Inflammatory bowel disease or hematopoietic disease</td>
<td>Subcutaneous arteriolosclerosis</td>
<td>Yes, caution with a superficial biopsy</td>
<td>Yes, caution with a superficial biopsy</td>
<td>Yes</td>
</tr>
<tr>
<td>Histologic feature</td>
<td>Laterodorsal leg, Achilles tendon</td>
<td>Acral, distal and proximal but not head</td>
<td>Proximal skin</td>
<td>Any location</td>
</tr>
<tr>
<td>Dense neotrophic infiltrates</td>
<td>Yes, caution with a superficial biopsy</td>
<td>Yes, caution with a superficial biopsy</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Antihypertensive, control of diabetes</td>
<td>Support kidney function, lower phosphate level, discuss sodium thiosulfate</td>
<td>Antihypertensive, control of diabetes, weight loss, discuss sodium thiosulfate</td>
<td>Immunosuppression</td>
</tr>
<tr>
<td>Systemic treatment</td>
<td>Debride necrotic material and split-thickness skin graft</td>
<td>Debride necrotic material and split-thickness skin graft</td>
<td>Surgery is contraindicated</td>
<td></td>
</tr>
<tr>
<td>Local treatment</td>
<td>Debride necrotic material and split-thickness skin graft</td>
<td>Debride necrotic material and split-thickness skin graft</td>
<td>Debride necrotic material and split-thickness skin graft</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: HYTILU, hypertensive ischemic leg ulcer; PTH, parathyroid hormone.
sic cardiovascular risk factors: long-standing arterial hypertension and diabetes. For disease management, it is of utmost importance that these diseases are not confused with PG or necrotizing vasculitis because their treatment is completely different (namely surgical), and exposing patients with tissue necrosis due to ischemic arteriolsclerosis to systemic immunosuppression may raise the risk of septicemia.

Future studies should address the role of the calcification protective matrix protein GLA, as well as the cytokine pattern during the inflammatory phase of progressive tissue breakdown that characterizes the aforementioned diseases causing ischemic arteriolsclerosis and skin lesions. Furthermore, morphological questions regarding the vascular pathologic mechanism (e.g., the role of calcification, intimal hyperplasia, and thrombosis) and the peculiar location of the skin necroses in Martorell HYTILU should be further studied. Therapeutic studies may help define the value of the nonsurgical approach using sodium thiosulfate compared with the surgical approach using early escharectomy and mesh grafting.

Accepted for Publication: February 6, 2010.

Correspondence: Jürg Hafner, MD, Department of Dermatology, University Hospital of Zurich, Gloriatrasss 31, CH-8091 Zurich, Switzerland (juerg.hafner@usz.ch)

Author Contributions: All of the authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Hafner. Acquisition of data: Hafner, Nobbe, Lauchli, Mayer, and Speich. Analysis and interpretation of data: Hafner, Nobbe, Parths, Lauchli, Mayer, Amann-Vesti, Speich, Schmid, Burg, and French. Drafting of the manuscript: Hafner, Nobbe, Parths, and French. Critical revision of the manuscript for important intellectual content: Hafner, Nobbe, Parths, Lauchli, Mayer, Amann-Vesti, Speich, Schmid, Burg, and French. Administrative, technical, and material support: Hafner, Nobbe, Parths, Lauchli, Mayer. Study supervision: Hafner, Parths, Schmid, and French.

Financial Disclosure: None reported.

REFERENCES


