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Caracterização tecidual de imagem fotográfica durante tratamento de úlcera venosa crônica: nota técnica

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Abstract

Chronic venous ulcers are a medical challenge with a socioeconomic impact. Tissue characterization was quantified by photographic imaging (p-CATIM) of a leg wound treated with Unna boot for 45 days. Three photographs, taken pre-treatment, post Unna boot and post healing were analyzed. Brightness on a 0-255 gray image was re-scaled with black as 0 and adjacent skin as 200. Gray Scale Median (GSM) and the percentages of pixels in each of 14 brightness intervals were calculated. Open ulcer GSM increased from 110 to 159 post Unna boot treatment, reaching 203 post healing. Predominant brightness intervals for the ulcer were 41-153 pre-treatment, 83% of pixels; 133-196 post Unna boot, 80%; and 175-255 post healing, 97%. The GSM of the subcutaneous wound around the ulcer increased from 117 to 137 post healing; the proportion of pixels in the 91-174 interval increased from 67% to 88% (p<0.001). CATIM quantified photographic changes during venous ulcer healing with comparison to the adjacent skin.

Keywords: venous insufficiency; ulcer; photography; quantitative analysis; healing.

Resumo

Úlcera de estase na insuficiência venosa crônica constitui desafio médico com impacto socioeconômico. Quantificamos caracterização tecidual por imagem fotográfica (f-CATIM) em ferida de perna tratada com bota de Unna por 45 dias. Três fotografias obtidas pré-tratamento, pós-tratamento com bota e pós-cicatrização foram analisadas. Brilhos em imagem cinza foram recalculados para nova escala no zero preta e 200 para brilho de pele adjacente à ferida. Mediana da escala cinza ou Gray Scale Median (GSM) e proporções de pixels em 14 intervalos de brilho foram estimadas. GSM da úlcera aumentou de 110 para 159 pós-tratamento com bota, atingindo 203 pós-cicatrização. Intervalos predominantes na úlcera: 41-153 pré-tratamento, 83% dos pixels; 133-196 pós-bota, 80%; 175-255 pós-cicatrização, 97%. GSM da ferida subcutânea ao redor da úlcera aumentou de 117 a 137 pós-cicatrização, de 67% a 88% dos pixels no intervalo 91-174 (p<0,001). CATIM quantificou evolução fotográfica de cicatrização de úlcera venosa comparada com pele adjacente.

Palavras-chave: insuficiência venosa; úlcera; fotografia; análise quantitative; cicatrização.

INTRODUCTION

Chronic venous insufficiency (CVI) is a common disease that can result in complications of significant morbidity, such as ulcers.[1] The high CVI prevalence directly affects many individuals' quality of life during the productive phase of their lives.[2] Treatment alternatives must be adapted to the slow healing processes and frequent recurrences.[3] The progress of ulcer treatment is documented photographically. One common variable quantified photographically is ulcer area.[4,5] This report describes an adaptation of the technique for tissue characterization based on ultrasonography (CATUS) to arrive at tissue characterization by imaging, in this case photographic imaging (p-CATIM). CATUS has been applied to analyze abdominal aneurysms treated with endoprostheses,[6] carotid and peripheral arterial atheromas,[7-9] venous thrombosis,[10] kidneys[11] and lymphedema.[12] In addition to providing measurements of area, p-CATIM also revealed granulation in a diabetic ulcer.[13]

The main objective of this study was to determine whether p-CATIM could describe the healing processes of a venous ulcer both qualitatively and quantitatively. P-CATIM was applied to 3 photos of a chronic venous ulcer taken pre-treatment, post Unna boot treatment and post healing. The photographic characteristics of the open-healed ulcer were compared with those of the adjacent skin.

CASE DESCRIPTION

The guidelines set out in the declaration of Helsinki were adhered to avoid patient identification. The patient was a 35 years-old woman who reported rupture of a varicose vein 15 days prior to the doctor's visit. The ruptured varicose vein, located in the medial, distal third of the right leg, developed into an ulcer (Figure 1). This shallow ulcer had regular edges and granulation tissue with hyperchromia. Induration cellulites was noted. The patient also stated that the leg had been swollen and red prior to occurrence of the lesion. She sought medical attention because of concern that the wound was not healing. Pain was not reported. Odor was not detected.

Clinical history included leg tiredness since age 19 and varicose vein surgery at 21. Venous symptoms, however, persisted and got worse after her second pregnancy, at age 27. The patient did not take contraceptives. She was taking Flavonid without medical prescription to treat leg tiredness, but stopped the medication once the wound appeared.

Physical examination demonstrated normal heart, 120×80 mmHg blood pressure, normal carotid and peripheral pulses, and hyperpigmentation in the distal third of the leg. Treatment included Duoflan. Secretion was minimal. Unna boots were applied a total of 3 times every 15 days. The patient used elastic stocking.

P-CATIM TECHNIQUE

Figure 2 shows photographs obtained pre-treatment, post Unna boot treatment, and post healing. These photos were analyzed using a p-CATIM technique adapted from CATUS. Each image was reformatted to gray scale with 256 levels of brightness amplitude. Differences between photos were minimized by re-scaling. The actual gray brightness per pixel was recalculated to fit a new scale along which black

Figure 1. Photographs of venous ulcer, taken pre-treatment, post Unna boot treatment and post healing.

equated to 0 and skin adjacent to the ulcer equated to 200. Gray scale medians (GSM) were calculated for each specific region selected in the photos. The percentages of pixels in each of 14 brightness amplitude intervals were estimated. Table 1 lists the intervals and the percentages of pixels that fell into each interval.

Ulcer GSM increased from 110 pre-treatment to 159 post Unna boot treatment, reaching 203 post healing. This 203 was similar to the 200 value ascribed to the adjacent skin. Therefore, the GSM increased from 55% (110/200) to 80% (159/200) of the skin value post Unna boot treatment, reaching similar skin brightness post healing (203/200).

Analysis of intervals with 10% increments in pixels demonstrated shifts in brightness as follows. Pre-treatment, the open ulcer had 83% of pixels in the 41-153 brightness interval. The brightness level increased post Unna boot treatment, by which point 80% of pixels fell in the 133-196 interval. Post healing, 97% of pixels had brightness within the interval 175-255. These proportions of pixels within distinct brightness intervals were different with statistical significance (p<0.05 by Chi-square).

The subcutaneous wound around the healed ulcer, however, continued to have lower brightness than the adjacent skin. The GSM of the subcutaneous wound increased from 117 pre-treatment to 137 post healing. The most common brightness interval of the subcutaneous wound post healing was 91-174. The percentage of pixels within this interval increased from 67% pre-treatment to 88% post healing.

Quality control included analysis of the original brightness of the adjacent skin (Table 1), which was

Figure 2. Characterization of tissue by photographic imaging (p-CATIM) of a venous ulcer of the leg. Three photos obtained pre-treatment, post Unna boot treatment and post healing. Additional analyses of subcutaneous wound pre-treatment and post healing. Column 1: original image. Column 2: image converted to gray scale with 256 levels of brightness amplitude. Column 3: histogram of number of pixels as a function of brightness. Column 4: bar histograms of percentages of number of pixels in each of 14 intervals of brightness amplitude. Gray scale median (GSM) depicted in between histograms. Column 5: ulcer and subcutaneous wound artificial colorization using 14 colors to represent brightness intervals. Relations between colors and brightness intervals are presented in Table 1.

Table 1. Percentages of number of pixels in brightness amplitude intervals for photographs of a venous ulcer in the medial aspect of distal third of the leg: Images 1, 2, 3: ulcer pre-treatment, post Unna boot treatment and healed ulcer; Images 4, 5: subcutaneous wound around ulcer pre-treatment and post healing.

Color	Gray Scale	Percentage of number of pixels per interval				
		Image 1	Image 2	Image 3	Image 4	Image 5
	GSM	110	159	203	117	137
	0-4	0.0	0.0	0.0	0.0	0.0
	5-7	0.0	0.0	0.0	0.0	0.0
	8-26	0.1	0.0	0.0	0.02	0.0
	27-40	1.5	0.0	0.0	0.3	0.0
	41-60	**11.1**	0.02	0.0	1.5	0.8
	61-76	**11.7**	0.4	0.0	7.7	2.5
	77-90	**10.5**	1.1	0.0	**14.3**	3.6
	91-111	**16.8**	2.2	0.0	**20.9**	**10.2**
	112-132	**17.5**	6.8	0.0	**28.1**	**25.2**
	133-153	**15.5**	**26.5**	0.2	**12.4**	**33.8**
	154-174	8.8	**37.4**	2.5	5.2	**18.7**
	175-196	1.9	**15.8**	**27.4**	4.0	4.7
	197-210	0.6	5.1	**44.4**	2.0	0.3
	211-255	4.0	4.7	**25.5**	3.6	0.1
	41-153*	83%*	37%	0%		
	133-196*	26%	80%*	30%		
	175-255*	6%	26%	97%*		
	77-153*				76%*	73%
	91-174*				67%	88%*
Quality Control	200**	153	133	159	151	166

GSM: gray scale median. *Predominant intervals with >10% of number of pixels in bold face. **Original brightness values for the skin adjacent to the ulcer, selected as reference 200.

then set as 200 on the p-CATIM common scale. The lowest skin brightness was 133, observed in the post Unna boot treatment photograph. This value of 133 was 25% smaller than the maximum skin brightness obtained from the other images. The coefficient of variability (mean/standard deviation) of the other 4 values was only 4%.

In summary, p-CATIM showed that the healed ulcer or its new skin became photographically similar to the adjacent skin; but the cutaneous wound continued to be different photographically, with lower brightness.

■ DISCUSSION

Human eye physiology perceives, on average, 16 shades of gray, which is 16 times fewer than the 256 levels commonly found in ultrasonographic images.[14] Software developed to characterize and differentiate gray scales increases visual perception and allows quantitative monitoring of medical conditions. Artificial colorization calls the attention of the observer to specific intervals. Quantification is based on calculation of the number of pixels per brightness interval.

This discovery level analysis has extended the CATIM technique to evaluation of venous ulcer healing. P-CATIM has previously documented photographic changes in a diabetic foot ulcer[13] and has been applied to thermographic images of a) the shoulders of a patient with acute thrombosis of a subclavian vein,[15] and b) neurogenic isquemia of the lower extremities.[16] Presently, the CATIM method minimizes variations by recalculating brightness amplitudes to fit a scale with standardized brightness at the 0 and 200 levels. In this case, the adjacent skin was the reference for the 200 brightness level. In retrospect, this re-scale was needed to correct brightness differences of the image obtained post Unna boot treatment. The constancy of skin brightness around 150, however, indicates that the CATIM software should have variable options for re-scaling. Intervals employed in this application were described in the literature.[6-13] Even without specific intervals for the venous ulcer evaluated, this study detected significant brightness changes after treatment. In particular, the GSM of the open ulcer acquired had, post healing, brightness similar to the adjacent skin. P-CATIM demonstrated that healed skin