

The Efficacy of Hyperbaric Oxygen Therapy in Improving the Quality of Life in Patients With Problem Wounds

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ABSTRACT: The unpredictable course followed by severe, chronic, non-healing wounds not only restricts the daily activities of affected patients, but also impairs their quality of life (QOL). Hyperbaric oxygen therapy (HBOT) treatment for such wounds elevates tissue oxygen content, increases cellular repair functions and the probability of wound healing, and improves the patient's QOL. This was a longitudinal, prospective study, and used a purposive sampling method. A total of 15 patients receiving HBOT at a medical center were enrolled. Data were collected by questionnaire before and after HBOT. The questionnaire included basic patient characteristics, self-perceived wound severity, wound physiological indices, and a QOL scale. The overall QOL score of the subjects after HBOT was higher than before HBOT. After HBOT, there was a positive correlation between the QOL of patients with problem wounds and the scoring of the Strauss wound classification system. After HBOT, there was a negative correlation between the QOL of patients with problem wounds and their self-perceived severity of the wound. The results were then used to provide suggestions for nursing care and additional research directions in order to effectively assist patients with problem wounds receiving HBOT, with the goal of achieving an optimal QOL.

Key Words: hyperbaric oxygen therapy (HBOT), problem wounds, quality of life (QOL).

Introduction

Hyperbaric oxygen therapy (HBOT) is a relatively new addition to the medical treatment armamentarium in Taiwan (Niu, 1998; Wang, Chen, & Guo, 1998). With high doses of oxygen, numerous biochemical, cellular, and physiologic effects can be achieved (Petzold, Feindt, Carl, & Gams, 1999). Clinically, HBOT is used as the primary therapy for decompression sickness, arterial gas embolism, carbon monoxide poisoning, and as an adjunctive therapy for gas gangrene, skin and flap transplants, and chronic, non-healing wounds (Leach, Rees, & Wilmschurst, 1998; Phillips, 2005). In conditions such as edema, vasculo-

pathies, hypovolemia, or local and systemic infections, there is tissue hypoperfusion and hypoxia which reduces cellular metabolism, decreases the efficacy of body defense mechanisms, impedes repair of injured cells, and attenuates white blood count, bactericidal function and wound healing, resulting in the formation of a chronic, non-healing wound (Leach et al., 1998; Strauss, 2000). Clinically, the treatment for the most problematic wounds consists of antibiotics, debridement, and skin transplantation, but the effects are limited; patient recovery is delayed, the hospital stay is increased in length, and the number of related tests and treatments is greater. Ultimately, the problem wound becomes a chronic medical condition (Butcher,

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1999). With HBOT, rapid healing was observed, the wound was closed and was completely epithelialized (Petzold et al., 1999). Taking into account the differences of individual patient characteristics and physiological wound indices, there are many occult variables of importance in the process of wound healing, resulting in changes in lifestyle, combined with social and environmental problems. These issues, in turn, directly impact on the patient's quality of life (QOL) (Teare & Barrett, 2002; Walshe, 1995).

In a review of the medical literature, Wunderlich, Peters, and Lavery (2000) analyzed patients with diabetes, gas gangrene, chronic osteomyelitis, necrotizing fasciitis, burns, or traumatic wounds. They found 76 publications which included patients undergoing HBOT, 49 of which involved human research, literature reviews, or case reports; the remainder of the publications were largely animal-based experimental studies. Most HBOT was conducted at a 2–2.8 atmosphere absolute (ATA), with an average treatment time of 90–120 minutes, and an average number of treatment sessions of 12–50. Collectively, the results demonstrated that HBOT promotes wound healing in 68–95.2% of cases, clearly consistent with significant clinical efficacy. It was surmised that HBOT reduced tissue hypoxemia, decreased the severity of the patient's wound, augmented wound healing in problem cases, and restored health (Petzold et al., 1999).

In step with social transitions, there has been an increasing demand among patients for healthcare services and the quality of services provided. This has resulted in a corresponding change in the provision of medical services, not only focusing on prolongation of life, but also the QOL (Ni, 1998). Healthcare providers have recognized that they not only need to help patients survive, but they must also help patients maintain or return to an acceptable level of QOL (Belcher, 1990; Petzold et al., 1999), and moreover, enjoy a high quality standard of life (Wu & Lin, 1997). In QOL studies derived from a MEDLINE search of the extant literature related to challenging wounds, whether the wounds were caused by diabetic ulcers or vascular insufficiency-induced ulcers, there were no studies comparing the QOL of patients before and after HBOT. Also, as Scully (1999), Teare and Barrett (2002), and Walshe (1995), pointed out, for most patients, ulcers involving the lower extremities are not an acute, but rather a chronic condition. Lower extremity ulcers often recur and disrupt skin integrity, and affect patients physically and psychologically. This motivated us to evaluate the efficacy of HBOT in

improving the overall QOL of patients with problem wounds, using a QOL scale as an evaluation reference in assessing patient treatment efficacy. We have also suggested possible areas of improvement for medical personnel who provide continuing care (Belcher, 1990; William, 2000) so as to deliver the most suitable health education and protocols for patients at different stages of wound healing in order to elevate the patient's overall QOL.

Methods

In light of the literature review, the conceptual model of this research is as follows (Figure 1). This study was a longitudinal, prospective study involving one group of subjects who were administered structured questionnaires before and after the treatment under evaluation. The subjects were patients with problem wounds receiving HBOT at a medical center. Hyperbaric oxygen therapy treatment is a form of therapy in which patients are placed in a sealed chamber, and 100% oxygen is supplied intermittently at pressures above 1 ATA. Oxygen pressure must be above 1.4 ATA to be of therapeutic value (Hampson, 1999; Yildiz et al., 2004). In this study, patients were placed in multi-compartmental chambers at a pressure of 2.5 ATA and a treatment time of 105–120 minutes. Selection criteria included: (1) a diagnosis of chronic and/or non-healing wounds, (2) requirement for HBOT as determined by a HBOT specialist, (3) 18 years of age or older, (4) clear consciousness and the ability to communicate, and (5) willingness to participate in the study and to complete the treatment.

This study used a two-stage purposive sampling method. The first stage was a preliminary experiment, administering the questionnaire to five patients with problem wounds. This stage was intended to test the reliability and validity of the questionnaire, to evaluate whether experimental tools were suitable for the task, to estimate the time needed to collect data from each individual, and to modify the questionnaire and study protocol to facilitate the collection of data. The second stage was the formal experiment. Researchers explained the purpose of the research and the methods to be utilized to the patients, obtained written consent, and then collected pre-experimental data, all of which took a total of 30–40 minutes. Questionnaires were provided after patients completed their treatment. A total of 15 valid questionnaires were collected. Since the sample size in this study was rather small, the central limit theorem was

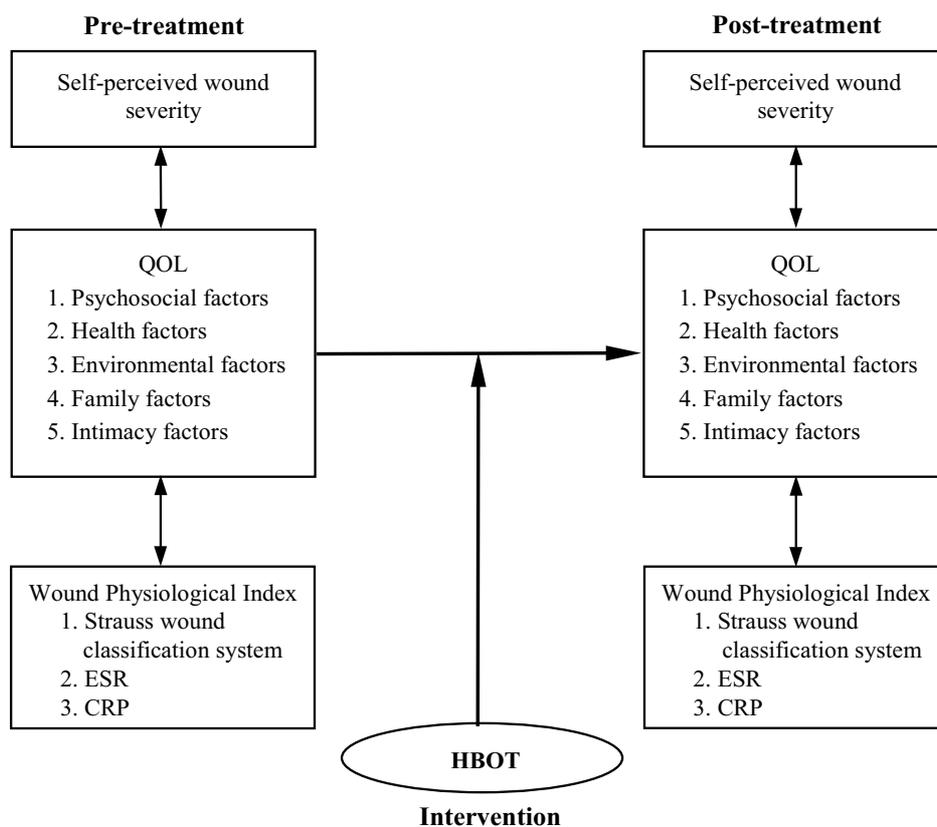


Figure 1. Conceptual Model: Comparison of data before and after hyperbaric oxygen therapy. *Note.* QOL = quality of life; ESR = erythrocytes sedimentation rate; CRP = C-reactive protein; HBOT = hyperbaric oxygen therapy.

applied and we confirmed to the sample recruiter was normally distributed.

The basic patient characteristics collected included: sex, age, marital status, education level, religious beliefs, primary diagnosis, and the date of wound occurrence. The information collected was collated and analyzed using a minimum number of categories while still preserving significant differences.

Self-perceived wound severity was a linear scale, with values from 1–10, with 1 being ‘not serious at all’ and 10 being ‘extremely serious’. In 1980, Zederfeldt suggested that problem wounds are defined as soft tissue damage which does not achieve satisfactory healing under standard therapeutic treatments (citations from Oriani, 1998). Alternatively, a problem wound can occur secondary to an interruption of the wound healing process, resulting in prolonged wound healing time. In the current study, a problem wound was considered to be soft tissue damage which did not heal after one month, with a score of less than 8 according to the Strauss wound classification system (Table 1). A distinction was made between

healthy and problem wounds by the differences in scoring, with a higher score corresponding to a healthier wound. The validity of this wound scoring system was 4.60 (range = 1–5), as determined by expert validity. The Cronbach’s α is used to assess the reliability of wound scoring in this study. The purpose was to understand the internal consistency of this scale. The value of α is between 0 and 1. A large value means a more reliable result. In this study α is 0.83. Which means the results obtained by using the wound scoring was reliable.

The erythrocytes sedimentation rate (ESR) and C-reactive protein (CRP) level of the patients were measured both before and after receiving hyperbaric oxygen. The ESR is a measure of the acute phase response, with a normal range of 10–20 mm/hr (He, 1992). The normal range for CRP is less than 0.8 mg/dL, with a value above the normal range consistent with an inflammatory reaction (Qi & Lee, 1998).

The current study relied upon the version of QOL indicators as developed by Ferrans and Powers (1985), and then translated into Chinese by Liu (1993). This QOL was

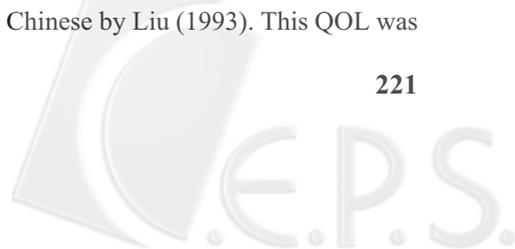


Table 1.
Strauss Wound Classification Scoring System

Criteria	Scoring*		
	2 points*	1 point*	0 point*
Appearance (wound base)	Red	Yellow or white	Black
Size	Thumb tip or smaller	Between thumb tip and fist	Larger than fist
Depth (deepest tissue exposed)	Skin or subcutaneous	Muscle or tendon	Bone or joint
Infection	None or superficial contamination	Cellulitis	Septic ⁺
Perfusion	Warm, pink, rapid capillary refill, palpable pulse	Cool, pale, sluggish capillary refill, and/or Doppler-detectable pulse	Cold, cyanotic, no capillary refill, and/or no pulse

Note. *Half points may be used when findings are intermediate between two scores or mixed (a wound appearance that is partially vascularized and partially covered with a fibrinous exudate). ⁺Findings associated with sepsis include fever, chills, leukocytosis, and/or uncontrolled blood glucose level.

developed to measure the quality of life of healthy individuals, as well as those who are experiencing an illness. It includes an individual's satisfaction with various aspects of life and the perceived importance of those features (Ferrans & Powers, 1992). In the current study, QOL was considered to be the state of contentment in a conscious individual due to their satisfaction in physiological, psychological, social, and spiritual aspects of life. After input from experts and subsequent modifications, a total of 37 questions were selected and divided into five dimensions: (1) social psychology, which probed an individual's psychological response to life and social interactions, (2) health, which was comprised of the health, life expectancy, stress, and healthcare conditions of the patient and the patient's family, (3) environment, consisting of the patient's personal living conditions and the general environmental conditions of Taiwan, (4) intimacy, including the relationship and intimacy between the patient and their spouse, and overall family happiness, and (5) family, involving the relationships between the patient and his/her siblings and the patient's satisfaction with their children. It is a six-point scale (i.e., zero to six), ranging from 'not applicable' (assigned a value of zero) to 'very important' or 'very satisfied' (assigned a value of six). The QOL score was represented by the weighted values of responses of the patients' satisfaction of life and their perceived relative importance. The lowest possible score, therefore, was zero and the highest possible score was 30. The higher the score, the higher the QOL. The reliability of this score was calculated by Cronbach's α coefficient, which indicated the internal consistency. The overall α coefficient was .96, and the α coefficient of the five questionnaire dimensions had

values of .67–.93. Validity was determined by expert validity, and the expert validity of this scoring system was 4.60.

After numerically labeling the data, descriptive and inferential statistical analyses were performed with SPSS/PC10.0 software. Inferential analyses used were the paired *t*-test to analyze the self-perceived wound severity, Strauss classification system score, ESR, CRP, QOL data before and after HBOT and the Pearson product-moment correlation to correlate self-perceived wound severity, Strauss classification system score, ESR, and CRP data with QOL. The value of *p* was set to be less than .05 for the significance level of the test.

Results

Some significant trends were noted amongst the 15 research subjects. There were 11 males (73.33%), nine were under the age of 68 years (60%), seven had completed a primary or junior high school education (46.67%), 13 were married (86.67%), 12 practiced a specific religious belief (80%), 11 had a primary diagnosis of diabetic foot ulcers (73.33%), seven had a wound duration of 3–6 months (46.67%), and 13 had wound surgery in conjunction with HBOT (86.67%).

The self-perceived wound severity in patients after HBOT was statistically lower than before HBOT (1.93 ± 1.33 vs 8.57 ± 2.21 ; $p < .001$). In accordance with the Strauss wound classification system, appearance, size, depth, presence or absence of infection, and perfusion status were used as a basis for evaluation. The wound score in patients after HBOT was higher than that before HBOT (8.80 ± 1.01 vs 5.33 ± 1.58), with a statistically significant difference before and after treatment ($p < .001$).

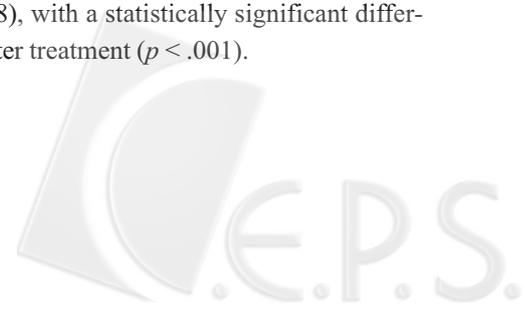


Table 2.
Differences in Overall Patient QOL Before and After HBOT

Categories	Hyperbaric Oxygen Therapy (HBOT)		t	p
	Pre-treatment	Post-treatment		
Overall	17.56	20.75	-5.74	.000
Social psychology	15.85	19.63	-3.60	.003
Environment	19.99	20.41	-0.72	.484
Health	13.61	23.90	-6.81	.000
Family	22.54	22.69	-1.68	.116
Intimacy	24.93	25.36	-1.47	.165

Note. QOL = quality of life.

The ESR in patients before receiving HBOT (39.25 ± 21.90 mm/hr) was higher than that after HBOT (34.67 ± 16.20 mm/hr), but the difference was not statistically significant ($p > .05$). The CRP level before HBOT (3.76 ± 5.87 mg/dL) was significantly higher than that after HBOT (0.38 ± 0.37 mg/dL; $p < .05$).

Before HBOT, the average score for overall QOL was 17.57 ± 5.95 , indicating a moderate level of QOL among the patients. Of the five main QOL dimensions, 'intimacy' had the highest score (24.93 ± 6.27), and 'health' had the lowest score (13.61 ± 6.74). Of the 37 minor categories, the five highest-scoring categories, in descending order, were 'family happiness', 'children', 'health of the family members', 'emotional support', and 'home'. In contrast, the five lowest-scoring categories, in descending order, were 'health', 'free from pain or physical discomfort', 'having control over what happens in life', 'having the ability to do something or being able to walk around', and 'able to travel during the holidays'. After HBOT, the average score for overall QOL was 21.92 ± 4.48 , indicating an upper-middle level of QOL among the patients. Of the five main QOL dimensions, 'intimacy' had the highest score (25.36 ± 5.52) and 'psychosocial' ranked the lowest (20.40 ± 7.25). Of the 37 minor categories, the five highest-scoring categories, in descending order, were 'medical care', 'family happiness', 'health', 'children', and 'free from pain or physical discomfort'. The five lowest-scoring categories, in descending order, were 'influence over local or central governments', 'having a job', 'work', 'pressure and stress', and 'overall situation in Taiwan'. There was a statistically significant difference in overall QOL before and after HBOT, as based on differences in the psychosocial and health dimensions (Table 2).

As shown in Table 3, the less severe patients perceived their wounds to be after HBOT, the higher their

Table 3.
Correlation Analysis Between Self-Perceived Wound Severity and QOL in Patients With Problem Wounds Before and After HBOT (r) (N = 15)

Item	QOL	
	Pre-treatment	Post-treatment
Self-Perceived Wound Severity		
Pre-treatment	-0.45	-
Post-treatment	-	-0.80**

Note. QOL = quality of life; HBOT = hyperbaric oxygen therapy. ** $p < .01$.

Table 4.
Correlation Analysis Between Wound Physiological Index (Strauss Wound Classification System) and QOL in Patients With Problem Wounds Before and After HBOT (r) (N = 15)

Item	QOL	
	Pre-treatment	Post-treatment
Strauss Wound Classification System		
Pre-treatment	0.48	-
Post-treatment	-	0.82**
ESR		
Pre-treatment	-0.39	-
Post-treatment	-	-0.11
CRP		
Pre-treatment	-0.39	-
Post-treatment	-	-0.42

Note. QOL = quality of life; HBOT = hyperbaric oxygen therapy; ESR = erythrocytes sedimentation rate; CRP = C-reactive protein. ** $p < .01$.

QOL. Moreover, patients who had a higher Strauss classification system score after HBOT had a higher QOL (Table 4).



Discussion

The overall QOL of patients was 17.56 points before HBOT. Of the five dimensions, 'intimacy' had the highest score and 'health' had the lowest. After HBOT, the overall QOL of patients was 20.75 points; the 'intimacy' dimension had the highest score and 'psychosocial' had the lowest score. In patients with problem wounds after HBOT, there was a significant negative correlation between QOL and self-perceived wound severity, and there was a positive correlation between QOL and the Strauss wound classification system score.

Within the five dimensions measuring patient QOL before and after HBOT, the 'intimacy' dimension pertained to family happiness, and the relationship and intimacy with the spouse. When not requiring HBOT, patients with problem wounds tended not to appreciate the care provided by the spouse and family members. However, when the wound did not heal and interfered with daily activities, and further medical treatment was needed, they appreciated the love and care they received from their family members. This is likely to be because HBOT is neither a well known nor widely accepted treatment in the medical field (Wang et al., 1998). Also, a course of HBOT requires continuous treatment for two weeks or longer. Because of the difficulties in traveling to and from hospital and also the enormous time consumed in the treatment process, family and spousal assistance and their psychological support were needed to encourage the patients to persevere with the treatment for an extended period of time. Therefore, the 'intimacy' dimension had the highest score. In this study, the 'health' dimension was related to aspects such as patient health, medical care, and freedom from pain or physical discomfort. Scully (1999) and Walshe (1995) pointed out that due to delayed wound healing, compounded by complications (e.g., infection or septicemia) aggravating the underlying condition, longer treatment time was required, which resulted in patients losing confidence in medical care or wound healing. If unbearable pain was also present, it directly threatened the patient, and therefore this dimension had the lowest score in patients before receiving HBOT. In this study, the 'psychosocial' dimension mainly disclosed the psychological reaction of patients with regard to their living conditions and social interactions. This dimension scored the lowest in patients after HBOT, because patients would like to walk around after their foot wounds had healed, but since the healing was fresh, most patients indi-

cated a need for further rest before they could walk confidently. There was a partial loss of control, so that compared with other dimensions, this dimension received the lowest score.

Before undergoing HBOT, regardless of the QOL score, every patient perceived their wound as very serious. Although the relationship between self-perceived wound severity and QOL before HBOT was not statistically significant, there was a widespread belief in wound improvement after HBOT. When the wound was no longer perceived to be severe, there was a statistically significant negative correlation between self-perceived wound severity and QOL after treatment. This finding affirmed the conclusion of Chen (2000) on 17 diabetic patients with early foot ulcers, in which there was an improvement in symptoms after HBOT according to the patients. It is known from the medical literature pertaining to patients with foot ulcers or osteomyelitis receiving HBOT that patients are distressed by their condition, and that if they can increase their ability to control their condition or reduce pain, there will be an increase in the degree of life satisfaction (Blixen & Kippes, 1999). As stated by Bertero and Ek (1993), QOL is a personal measurement, and different disease severity impacts on the QOL of different individuals in different ways.

Problem wound sickness in accepts before the HBOT, no matter the QOL scores points the height, each problem wound on the Strauss wound classification scoring system, all belongs to the difficult wound or the non-hope wound. The serum test of ESR and CRP, mean value all indicated has serious or the slight infection existence, The result were not reveal the correlation existence with the life quality. It is because problem wound sickness in the physiological data obviously all indicated has the infection existence, but each person's aware degree is different. Some people thought extremely affects the life, but others not. Therefore was no correlation with the life quality.

There was a positive correlation between the Strauss wound classification score and QOL, indicating that HBOT has the advantage of reducing wound size and decreasing amputation rates after therapy (Simmons, 1999; Wu, Li, & Lin, 2000). Wang (1994) pointed out that in problematic wounds, such as chronic ulcers, diabetic foot ulcers, and ischemic skin flaps, the vascular supply of the wound is inadequate, so HBOT is needed to enhance wound healing. In discussing clinical applications of HBOT, Wang et al. (1998) suggested that in managing tissue hypoperfusion, non-healing or problem wounds, HBOT was of significant

therapeutic value. Dong and Guo (1995) summarized the application of HBOT in plastic surgery, showing that they aided wound healing, especially in cases of delayed healing. This line of research indicated that in such patients, their wounds not only healed subjectively, but pathophysiological examination results also showed that infection was under control, and the wound condition improved significantly. Patients felt their lives were no longer affected by their wounds. Evidently, the healthier the wound, the higher the patient's QOL.

Suggestions and Limitations

From the results of this study, in practical nursing care, 'health' and 'psychosocial' had the lowest points of the five QOL dimensions before and after HBOT. These are the areas to be strengthened for nursing personnel in educating patients with difficult wounds receiving HBOT in the future. Due to restrictions in time and manpower, we only examined the differences which existed before HBOT and immediately after therapy. We found significant differences in QOL before and after HBOT, and we suggest that future research should continue to follow up patients' QOL six months and one year after HBOT. Also, due to payment issues in the National Health Insurance system, we only collected data pre-experimentally using a single-group, pretest-posttest method from patients with problem wounds in one hospital in northern Taiwan. The number of subjects was small and may not be representative of the general population. There were many independent variables which we wished to examine. The subjects themselves were special cases, so the statistical significance of results was probably affected. Future related research should cover the entire northern, central, and southern areas, and compare the QOL in patients with problem wounds of different characteristics before and after HBOT. During the study, it was determined that factors such as extent of social support of the patient, degree of distress caused by the disease, changes in self-image of patients with problem wounds, and the stresses and coping behaviors resulting from the disease all affected the QOL of patients undergoing HBOT. Future research should include the above-mentioned variables in their analyses.

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高壓氧氣治療對困難傷口病人生活品質 改善之成效初探

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摘要： 困難傷口帶來的困擾及其未知性，不但限制病人的日常活動，更使得病人生活品質受到損害；高壓氧氣治療對困難傷口，可提高組織的含氧量，增加細胞修復功能與傷口康復的機率，以助改善病人的生活品質，故本研究主要目的是探討高壓氧氣治療對困難傷口病人生活品質之成效。此研究為縱斷式前瞻性研究，採立意取樣方式，對象為某醫學中心接受高壓氧氣治療病人計 15 人，在接受高壓氧氣治療前、後，分別利用問卷蒐集資料，問卷包括個人基本特性、自覺傷口嚴重度、傷口生理指標及生活品質量表，結果顯示：(1)研究對象的整體生活品質，在高壓氧氣治療後比治療前的得分高 (20.75 分 > 17.56 分)；(2)高壓氧氣治療後之困難傷口病人的生活品質與 Strauss 傷口分類系統呈現正相關；(3)高壓氧氣治療後之困難傷口病人的生活品質與自覺傷口嚴重度呈現負相關。藉由結果對護理實務及研究等方向提出建議，以期有效協助高壓氧氣治療之困難傷口病人獲得滿意的生活品質。

關鍵詞： 高壓氧氣治療、困難傷口、生活品質。

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