Effect of Beloved Person's Voice on Chest Tube Removal Pain in Patients Undergoing Open Heart Surgery: Fuzzy Logistic Regression Model

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ABSTRACT

Chest tube removal pain is one of the most important complications after open heart surgery. The removal of a chest tube is a painful and frightening experience and should be managed with as little pain and distress as possible. The aim of this study is to assess the effect of beloved person's voice on chest tube removal pain in patients undergoing open heart surgery. 128 patients were randomly assigned to two groups: one group listened to beloved person's voice during the procedure, and the other did not. Since pain was measured by linguistic terms, a fuzzy logistic regression was applied for modeling. After controlling for the potential confounders, based on fuzzy logistic regression, the beloved person's voice reduced the risk of pain. Therefore, using beloved person's voice could be effective, inexpensive and safe for distraction and reduction of pain.

Keywords: Beloved person's voice; Pain; Chest tube removal; Fuzzy logistic regression

INTRODUCTION

According to annual report of American heart association, more than 448000 patients suffer from open heart surgery, valve replacement and valve repair [1]. Chest tubes are used to remove air or fluid or pus from around lungs [2]. One of the cares after open heart surgery is to control the pain of chest tube removal [3]. Although pain is a predictable part of after operation, insufficient pain management is prevalent and has profound effects. There are various pharmacological and non-pharmacological methods to reduce pain in these conditions; non-pharmacological methods are advantageous, non-invasive and may be used easily by the nurses [4]. Researchers suggest various non-pharmacological pain management methods [5-10]. Broscious (1999) surveyed the effect of a relaxation technique taught to patients before chest drain removal in randomized, controlled design. Patients are divided into three groups (white noise, music of the patient's choice, and control). There was not any difference in pain between the three groups at any stage. Sauls (2002) compared the effect of ice with placebo for chest drain removal pain in 50 adult patients and concluded that there was no difference in pain scores between the two groups. The effect of cold application on pain due to chest tube removal was studied by Ertug and Ulker (2012) in two groups of patients and concluded that cold application was effective in reducing the pain owing to chest tube removal. Music is a nursing intervention that has no side effects and can be effective among other methods [6]. The effect of music on postoperative pain in patients undergoing open heart surgery was surveyed by Mirbagher Ajorpaz (2014) and showed that there were significant differences between the two groups prior and after the intervention. Effect of natural sounds was surveyed by Saadatmand (2015) and showed significant differences. Our aim was to survey the effect of beloved person's voice on chest tube removal pain in patients undergoing open heart surgery. Pain is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage" [11]. Pain is a subjective experience, and no objective test exists to measure it (American Pain Society, 2009). Whenever possible, the

existence and intensity of pain are measured by the patient's self-report (McCaffery, 1968). Therefore, pain status is basically evaluated by verbal reports and linguistic variables while borderlines of categories of linguistic variables are not crisp [12]. The reported borderline between subcategories of patient status that has been reported is vague. Since fuzziness must be considered in modeling systems, human estimation is influential [13]. So, it is preferred to apply fuzzy logistic regression to modeling the effect of voice of beloved person in pain reduction. Fuzzy regression model is a soft method that can be implemented for the modeling in vague response.

MATERIALS AND METHODS

Study Population and Sampling

A randomized control clinical trial study was performed on 128 patients (64 patients in each group) undergoing open heart surgery who referred to ICU of the Shafa Hospital in Kerman city in Iran, in 2013. All patients studied the consent form and participated with the consent in this research. Samples were excluded from the study in cases such as; hearing loss, visual impairment, drug addiction and mental defect. Hospitalized patients were selected through targeted based method, and then were divided into two groups through random assignment. Table of random numbers were used for group allocations. The clinical and demographic characteristics of the patients were obtained from their medical files. Postoperative care was performed for each group. The patients in experimental group listened to beloved person's voice during procedures by an MP3 player with headphones. Lengths of voices were 5 minutes. The patients in the control group put on headphones, but heard nothing. The participants were asked to provide a self-reported VAS pain score before and after chest tube removal procedure.

Data Analysis: Fuzzy Logistic Regression

Logistic regression is a statistical method to analyze a dataset in which there are one or more independent variables that determine a response. The response is measured with a binary variable. In binary logistic regression, the response variable (*y*) has binomial distribution, and it can take the value of 1 with a probability of success π; or the value of 0 with probability of failure 1-π. The legit transformation of π is used for modeling the relationship between the independent variable and response variables, and the model is defined as follows:

$$\ln\left(\frac{P(y_i=1)}{1-P(y_i=1)}\right)=b_0+b_1x_1+\ldots+b_px_p$$

Where $X=(x_1,x_2,\ldots,x_p)'$ vector of independent variables, $y_i=0,1;i=1,2,\ldots,n$ is responsevariable and $b_0,b_1,\ldots,b_p$ are regression coefficients and $\frac{\pi}{1-\pi}$ is probabilistic odds that is defined as the ratio of the probability to its complement, or the ratio of favorable to unfavorable cases [14]. In some medical studies, the response variable is measured by linguistic terms such as very low, low, medium, high, and very high, rather than by exact values. These linguistic terms detect the status of each case relative to the binary response categories when participants' status relative to response variable is evaluated by linguistic terms where the binary response cannot be defined exactly. Therefore, Bernoulli distribution cannot be considered for such responses; so the probability of success cannot be calculated and therefore, the probabilistic odds are meaningless [15]. Moreover, it is not appropriate to apply quantitative numbers for the subjective qualitative terms of a linguistic variable, because this could leave out useful information for modeling [16]. An approach to this problem, which was initially proposed by [17, 18] is to rate the possibility of success for each observation by defining a proper fuzzy number for each term of the linguistic variable. These fuzzy numbers should be defined in such a way that their support covers the whole range of 0, 1[19].

(See appendix). In this study, pain has a subjective quality and was measured by linguistic terms. Definitions of linguistic terms, which detect the possibility of having pain, are important.

One definition is suggested for the possibility of having pain, (μ: approximately zero, approximately 0.1… approximately 1), in the form of triangular fuzzy numbers as shown in Figure 1.

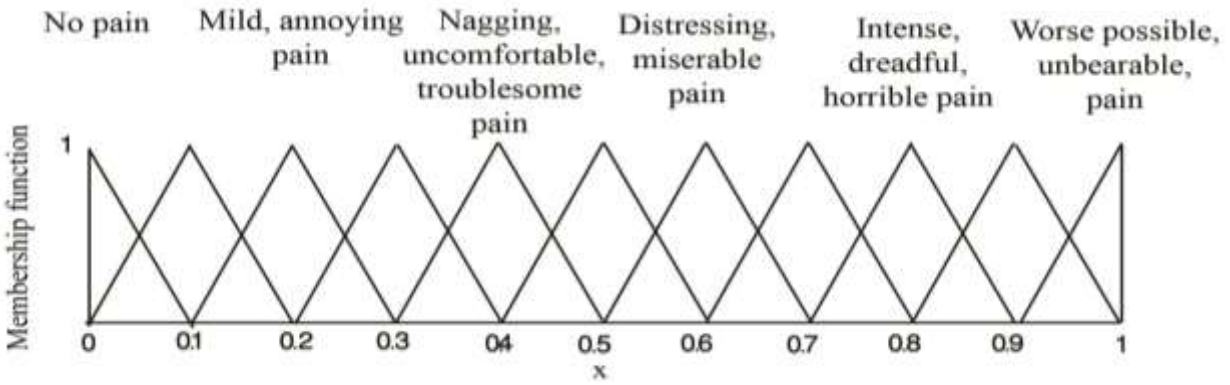

Figure 1. Membership functions of the pain linguistic terms

The definition for Fuzzy number and number are defined as:

$$\text{approximately } 0(x)=\begin{cases}1-\dfrac{0.02-x}{0.01} & 0.01\le x<0.02,\\ 1-\dfrac{x-0.02}{0.1} & 0.02<x\le 0.1,\end{cases}$$

$$\text{approximately } \ i(x)=\begin{cases}1-\dfrac{i-x}{0.1} & i-0.1\le x\le i,\\ 1-\dfrac{x-i}{0.1} & i\le x\le i+0.1,\end{cases} \qquad i=0.2,0.3,...,0.9$$

$$\text{approximately } \ 1(x)=\begin{cases}1-\dfrac{0.99-x}{0.1} & 0.89\le x\le 0.99,\\ 1-\dfrac{x-0.99}{0.01} & 0.99\le x\le 1.\end{cases}$$

In order to fit the fuzzy logistic model, we should model logarithm transformation of possibility odds. $\ln\dfrac{\mu}{1-\mu}$ with linearity dependent independent variables as follow:

$$\ln\frac{\mu_i}{1-\mu_i}=\tilde{\beta}_0+\tilde{\beta}_1 group_i+\tilde{\beta}_2 age_i+\tilde{\beta}_3 sex_i \qquad i=1,2,...,128$$

In which $\tilde{\beta}_0,\tilde{\beta}_1,\tilde{\beta}_2,\tilde{\beta}_3$ are fuzzy coefficients, which indicate fuzzy relationship between the independent variables. The coefficients are assumed symmetric triangular fuzzy number. Statistical analyses were performed using Matlab and SPSS16.

RESULTS

Participants in the study included 128 patients undergoing open heart surgery. The mean ±SD of age was 6.7±13.39 years in control group and 50.6±13.22 years in experimental group. 68% of patients were male. Two groups of patients are individually matched for sex (P=0.18) and education level (P=0.55) and unmatched for age (P=0.003). Center of fuzzy number was used for before pain and no significant difference was observed between the pain in experimental and control groups before intervention (P=0.87) (Table 1).

Table 1. Demographic Characteristics of Study Participants

Variable		Experimental Group	Control Group	Statistical Test
Sex, n (%)	**male**	40 (62.5%)	47 (73.4%)	Chi-square= 1.76 P=0.18
	female	24(37.5%)	17(26.6%)	
Educational level	**Primary**	47(73.4%)	51(79.7%)	Chi-square =1.21 P=0.55
	High school	11(17.2%)	10(15.6%)	
	Academic	6(9.4%)	3(4.7%)	
Age		50.6±13.22	56.7±13.39	t=3.02 P=0.003
Pain before chest tube removal		1.44 ± 1.66	1.48 ±1.73	t=0.16 P=0.87

The relationship between pain level and beloved person's voice was evaluated by the means of regression modeling and through adjusting the effect of age that may have an effect on pain. The estimated regression parameters are shown in Table 2.

Table 2 . The estimated fuzzy logistic regression parameters

parameters		Fuzzy logistic regression			Linear regression		
		M	spread		Beta	SE	P-value
Intercept		2.38	0.56		8.16	0.76	<0.001
Group (1=intervention , 0=control)		-2.81	0		-4.26	0.39	<0.001
Age		-0.01	0		-0.32	0.3	0.285

To sum up, the estimated positive coefficients in fuzzy logistic regression show that corresponding variable is related to an increase in possibility odds of having more pain, and negative coefficients indicate that the corresponding variable is related to a decrease in possibility odds of having more pain. After controlling for the confounders, both regression models showed a negative effect of group variable (Table 2). The results of multiple linear regression analysis for crisp observation are presented in Table 2. In this model, after controlling for the potential confounders, a negative relation between the level of pain and group variable was detected.

DISCUSION

There are a lot of methods for reducing postoperative pain based on drugs intervention. And yet, non-pharmacological interventions are noninvasive and safe methods. There are various methods of distraction therapy that Musical therapy is one of non-invasive method. Music reduces heart rate, blood pressure, body temperature and respiration rate; it also distracts the attention of the patient, thus reducing the pain [20]. The purpose of the present study was to assess the effect of beloved person's voice as a non-pharmacological method in reducing postoperative pain. Here, the beloved person's voice intervention as a non-pharmacologic intervention may serve as a means of distraction. Based on statistical results, this intervention significantly decreased pain. This finding is consistent with previous studies that used different type of musical distraction.

[21]It has been found that music reduced pain of patient undergoing open heart surgery. [22] It aslo showed that listening to live harp music had a positive effect on vascular and thoracic patients. [23] Audiovisual distraction was used for pain reduction perception during shock wave lithotripsy and showed significant effect. [24] Music intervention was used for people diagnosed with fibromyalgia and showed a significant reduction in pain and depression in treatment group.

When the assumptions of statistical models, such as distribution assumptions, adequate sample size, and exact observations are not established, fuzzy regression is considered as an appropriate method [12]. In this study, pain is measured through linguistic terms; fuzzy logistic regression was applied here, which is conceptually easy and useful for modeling vague observations that are measured by linguistic terms. The fuzzy logistic regression model can be used in other research areas with similar situations.

CONCLUSION

In this study, it was demonstrated that using beloved person's voice can be effective, inexpensive and safe for distraction and reduction of pain and can be applied by clinical nurses without special training to alleviate pain without risking unwanted adverse effects. Non-pharmacological methods for pain reduction is well cooperated and accepted by all patients.

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APPENDIX

Fuzzy numbers

A crisp set is defined as a collection of elements of a universal set; each single element can either belong to or not belong to the set. In such a classical set, we can relate a membership value to each element by using an indicator function, in which 1 and 0 indicate membership and non-membership, respectively. But for a fuzzy set, which is vague in defining its members, the indicator function allows various degrees of

membership for the elements of the universal set [19]. Let X is a universal set. A fuzzy set $\tilde{A}$ of X is defined by its membership function $\tilde{A}: X \rightarrow [0,1]$.

Definition

Let L (and R) be decreasing, shape functions from $\square^{+} \cup \{0\}$ to [0,1] with $L(0)=1; L(x)<1$ for all $x>0, L(x)>0$ for all $x<1; L(1)=0$ or ($L(x>0)$ for all x and $L(+\infty)=0$). Then fuzzy number M is called of LR-type if for $m, \alpha>0, \beta>0$ in $\square$

$$\tilde{A}(x)=\begin{cases} L\left(\frac{m-x}{\alpha}\right), & x \le m \\ R\left(\frac{x-m}{\beta}\right) & x > m \end{cases}$$

Where m is called the mode of $\tilde{A}$, and α and β are called the left and right spreads, respectively.

Symbolically, M is denoted by $(m, \alpha, \beta)_{LR}$.

In special case,

where $L(x)=R(x)=\max(0,1-|x|)$, $\tilde{A}$ is called triangular fuzzy number and is denoted by $(m, \alpha, \beta)_T$ and its membership function is

$$\tilde{A}(x)=\begin{cases} 1-\frac{m-x}{\alpha} & m-\alpha \le x \le m \\ 1-\frac{x-m}{\beta} & m < x \le m+\beta \end{cases}$$

If, in addition, $\alpha=\beta, \tilde{A}$ is called symmetric triangular fuzzy number and is denoted by $(m, \alpha)_T$ [25].

"The authors declare no conflict of interest"

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