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Simulation Research on a New Spot-First-Aid of Foreign Body Asphyxia in the Hypopharynx

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Abstract

Airway suffocation is a kind of unexpected emergency. The author's research group proposed a new spot-first-aid method of foreign body asphyxia in the hypopharynx, and compares it with traditional "Heimlich Maneuver" first aid method by simulation comparative study. This article mainly introduced the main contents and methods of the research, primarily on: the processing of CT Imaging data, including: Visual C++ program is used to realize the contour extraction algorithm processing based on CT images pre-processing, and restore the respiratory organs in asphyxia status in the processing of image morphology. Compare the two spot first aid methods by simulation. The Main research steps including: establishing simulated equivalent circuit simulation to compare two different spot first aid methods influence on the change of respiratory airway pressure and the animals steps of the experiments.

Keywords*: foreign body asphyxia, Heimlich maneuver, new spot-first-aid method, simulation research, Visual C++*

1. Introduction

Foreign body in respiratory tract is frequent emergency with short disease duration and high mortality rate. Foreign body asphyxia can be a life-threatening emergency. The most effective time after the foreign body asphyxia of on-the-spot first aid is only 5 minutes, which is called "5-minute prime time" [1-2]. The most important question to consider is: How to provide a quick, effective treatment and avoid the occurrence of complications in the "prime time"?

At present, the traditional spot-first-aid methods just like "Heimlich Maneuver" emergency procedure is easy to make the patients attacked by the foreign body asphyxia suffer syndromes frequently and great injuries, and the success rate of these methods are low as well [3-5].

For this reason, the research groups in the units where the authors work carry out a simulation the existing operation practice (Heimlich Maneuver emergency procedure) of the spot-first-aid for the Foreign body asphyxia and trying to take full advantage of the digital analog simulation emergency process.

The research group in this paper carries out the innovation on the spot-first-aid methods for the foreign body asphyxia through the 30-year clinical experience, This new first aid method is useful because a clinician can administer it anywhere, anytime, and have successfully treated a number of patients by the new method. In the meantime, the authors make use of the three-dimensional reconstruction way (Inverted Shock Maneuver emergency procedure) of the human respiratory system to conduct a simulation on the new treatment method concluded in clinical practice for the foreign body asphyxia, and then a conclusion is drawn up. The purpose of this paper is providing a new, vivid and effective way for the emergency medicine.

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2. Materials and Methods

Simulation details.

2.1. Data Sources

In this study, the three-dimensional reconstruction data that is applied by the authors sourced from the CT imaging materials of the affiliated hospital of Gannan Medical University in Jiangxi Province. Besides, the human tissue organ materials came from the archives of anatomy teaching and case histories. The data visualization is this research foundation.

2.2. Software Tool

At present, LifeMod (Multi-Body dynamics simulation software) is the advanced human body dynamics simulation software in the world. LifeMod automatically produces standard plots of force, displacement, velocities, accelerations, torques, and angles. These powerful post-processing capabilities make creating clear, concise reports and attention-grabbing presentations complete with animations, plots, and charts. This simulation software is an excellent simulation tool.

The simulation experiment, which is introduced in this paper, is put into implementation under the environment of this software.

2.3. Methods and Ideas

First of all, the members in the research group get an understanding of a great number of the basic structures of the respiratory tract of human being.

Second, the research group's members that devote themselves to the anatomical major carry out a description on the shape and characteristics of the respiratory tract of the normal human being.

Third, the materials used in this paper about the case histories of the respiratory tract foreign bodies are collected, and the description on the characteristics of the shape change is conducted for the data with images.

Fourth, the simulation model is established so as to carry out an analog simulation on the foreign body asphyxia in the human respiratory tracts.

Fifth, the simulation and comparison research are conducted for over two spot-first-aid methods.

3. Research Contents and Implementation Steps

3.1. Data Pre-Processing Based on CT Imaging Materials

The spiral CT can get the small-spacing tomography sequences. In this paper, what the authors discuss is the surface reconstruction that is based on the fault profiles; the surface reconstruction of the fault data is deducing the corresponding geometric structures from the fault profile lines of a series of fault surfaces.

3.2. Segmentation and Acquisition of Vital Organs

One of the most important tasks of this paper is carrying out a correct and reasonable segmentation on the CT imaging data, which were provided by the volunteers. The vital organs and tissues of the foreign bodies choking should be extracted from the segmented areas. Then, it is necessary to carry out a three-dimensional reconstruction to the extracted organs and tissues.

The medical image segmentation has not achieved a consistent standard in the medical community at the present time. For this reason, the authors consult the research

experience and methods that were used by the predecessors in the previous time, and take advantage of the automatic segmentation method for the operation at the same time. In the previous time, and take advantage of the automatic segmentation method for operation at the same time. In other words, after the CT original images undergo a noise reduction processing, a binary image processing can be implemented for the images under two circumstances, which are normal range and stress threshold respectively [6]. In consideration of the edge image points produced by the binary image, the authors take advantage of the Matlab image import method, the mathematical morphological operation, the matrix generation and the double circularities to implement the processing. Finally, it is necessary to fill the seed, acquire the vital organs and referential parts for the asphyxia caused by the foreign body in the human respiratory tract.

3.3. Contour Extracting

In this study, the research group used the most basic morphology algorithm to get the contour of all these images. The morphological algorithm provided boundary line, connecting components of an organ area and foreign body is very effective. The contour extracting algorithm is designed to get the outer contour of the images. Binary image have black and white two gray scales, "1" represents black, "0" represents white. The contour extracting algorithm of binary image is to remove the internal point of the image [7, 8]. Extraction methods used in this study is: given a binary image, the black areas seen as objective, seen as a white background. Seen enter each black pixel point of the image, if the gray value of eight pixels of the field and around the point 0, the point is an internal point, the corresponding position pixels of output image were set to white.

This part of the algorithm has been realized by Visual C ++, codes as follows:

```
/**********************************
*Function Name：ContourExtract()
*Parameters: None
*Return Value: None
**********************************/
Void ImageSegment:ContourExtract()
{
If (m_nBitCount! =8)
Return;
//Processed grayscale image
m_pImageOut=new unsigned \ char [lineByte*m_imageHeight];
// Application output buffer
m_nBitCountOut=m_nBitCount;
// The output image and the input image have the same type
m_imageWidthOut=m_imageWidth;
// The width of the input image and the output image are equal
m_imageHeightOut=m_imageHeight;
// The height of the input image and the output image are equal
int \  lineByte=(m_imageWidth*m_nBitCount/8+3)/4*4;
// The same bytes of pixels per line in the output image and the input image
memcpy(m_pImageDataOut,m_pImageData,line \ Byte *m_imageHeight);
// copy the input image data to the output image buffer
int array[8];
// Store the black pixels 8 pixel neighborhood gray value
int sum=0;
// Summation Array
int i,j,k;
// Loop variable definition
For (i=1; i<m_imageHeight-1; i++)
```

```
// Search for black spots in the image, without regard to the point on the boundary
{
For (j=1; j<m_imageWidth-1; j++)
{
// Find a black spot
If (*(m_pImageData+i*lineByge+j) ==0)
{
// Copy 8 pixels neighborhood into an array
Array [0] =*(m_pImageData+i*lineByte+j+1);
Array [1] =*(m_pImageData+ (i+1)*lineByte+j+1);
Array [2] =*(m_pImageData+ (i+1)*lineByte+j);
Array [3] =*(m_pImageData+ (i+1)*lineByte+j-1);
Array [4] =*(m_pImageData+ i*lineByte+j-1);
Array [5] =*(m_pImageData+ (i-1)*lineByte+j-1);
Array [6] =*(m_pImageData+ (i-1)*lineByte+j);
Array [7] =*(m_pImageData+ (i-1)*lineByte+j-1);
For (k=0; k<8; k++)
Sum +=array[k];        // Sum array
If (sum==0)
*(m_pImageDataOut+i*lineByte+j) =255;
// if the gray value of 8 pixel points around the field and is 0, the position corresponding to the output image is set to white.
}
}
}
}
```

3.4. Simulate the Suffocation of Foreign Body Airway Congestion State by Using the Bulge Algorithm

When organisms in foreign body suffocation, due to breathing difficulties leading to airway swelling and contracting sharply, the true reflection is airway tissue after stress to external expansion, the whole airway hyperemia swelling process. The research group restored the swelling deformation image of laryngeal and pharyngeal soft tissue in asphyxia by bulge algorithm. The research idea as follows: suppose the foreign body for structural elements, based on expansion of the normal respiratory organisms restructuring operation, contact with the object of all the background point merge into the object, make the boundary to external expansion process. Hypothesis "*A*" for the respiratory organ image of the organism, "*F*" as the foreign body, expansion structure element "*F*" is used to image object "*A*", assuming that expansion process are defined with the shifting method, press "*F*" each non-zero elements in the "*A*" displacement on the relative position of the origin [9]. Finally, integrate all the displacement results "OR" operation to get inflation image.

Another article will discuss the bulge algorithm used to deal with the status of the respiratory organs under suffocation expansion.

3.5. Two Methods to Carry Out the Analog Simulation on the Foreign Body Asphyxia in the Respiratory Tract

In accordance with the operation characteristics of the commonly traditional spot-first-aid method (Heimlich Maneuver emergency procedure) for the foreign body asphyxia in the human respiratory tracts and the new method (Inverted Shock Maneuver emergency procedure) that is researched and tested in this study, the different boundary conditions

and load condition can be added on the basis of the already-established human respiratory tract model.

Then, the "inverse dynamics" and "positive dynamics" are utilized to carry out a simulation [10]. Then, a comparison is necessary to be made on the simulation results and the animal experimental results, and the rationality of the simulation results is analyzed as well.

For example, the relevant parameters are adjusted if there are any unreasonable factors in the model, and the simulation process can be repeated over and over again until the simulation ends.

3.6. Animal Supplement Experiment

First of all, the authors carry out a summary on the most important technological points of the spot-first-aid operation methods including "Heimlich Maneuver" emergency procedure in a traditional sense and the new Inverted Shock Maneuver emergency procedure for the foreign body asphyxia in the human respiratory tracts.

Second, the authors carry out an animal practice supplement experiment according to the guidance method.

Third, in the combination of the stress response simulation results of the human bodies when suffering from the foreign body asphyxia in the human respiratory tracts and the comparison results of the analog simulations of two spot-first-aid methods, the authors carry out a comparative calculation on the models of the different ages of human bodies, and comprehensively process and analyze the data of the experiment, and also conduct a further analysis and conclusion on the roles, influences and principles of two spot-first-aid methods on the discharge of the foreign bodies that exist in the respiratory tracts.

4. Results and Discussion

4.1 Image Border Extracting

Following diagram shows the contour extraction processing example, in which Figure 1 is the original image; Figure 2 is the result of the contour extraction.

Figure 1. Epiglottis Image

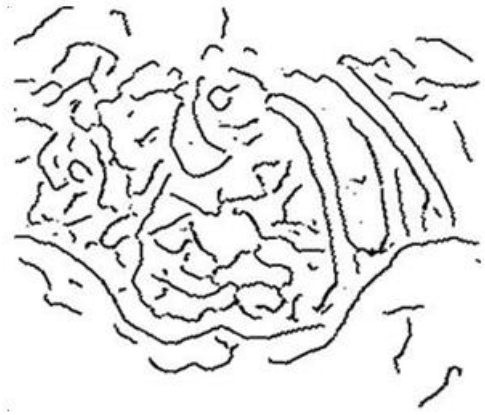

Figure 2. Epiglottis Outline

It can be seen contour extraction algorithm can extract the inside outline of the target image.

4.2 Comparison of Two Methods on First Aid Simulation

Firstly, the research group reference mechanics classical modeling method of mechanical system, established the related force and displacement of the linear mechanical system:

$$f = KX + R\dot{X} + M\ddot{X}$$

The f represents the force; X indicates that displacement; $\dot{X}$ represents the velocity in first-aid techniques, $\ddot{X}$ for acceleration, (such as: first aid impact velocity of impact method)

The K represents the linear elastic coefficients, R indicates the linear frictional resistance coefficient; M for the inertia force coefficient.

The second is established simulation equivalent circuit.

“The Heimlich Maneuver" is widely used, and this research group summarizes the research of "Inverted Shock Maneuver" in a certain range successfully treated many patients with respiratory laryngeal pharynx ministry foreign body choking, the research group assumed the key factors influencing the treating results hypothesis as: spot first-aid operation techniques change the pressure of lungs and airway resistance that the role about the two main parameters of respiratory tract [11].

The one-order linear model represents the Movement of respiratory is:

$$P = \frac{V}{C} + R\dot{V} + I\ddot{V}$$

Among them: P is force, V is capacity, C for compliance, R for resistance coefficient, I for inertia coefficient.

The Figure 3 simulation of equivalent circuit diagram, including:

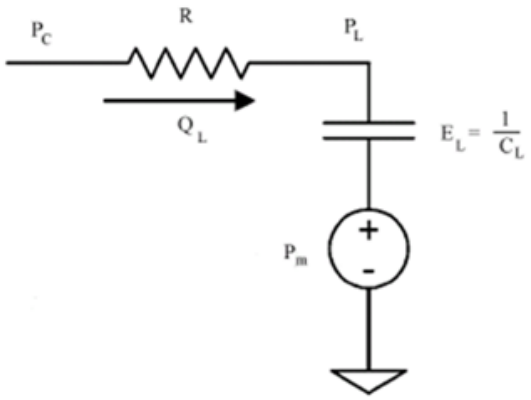

Figure 3. The Simulation of Equivalent Circuit Diagram

Parameter specification:
PC is Inlet pressure;
QL is the flow of air into the lungs;
R is airway resistance;
EL is lung volume;
PL is lungs pressure;
Pm is simulating the muscle of respiratory effects;
The inductor represents equivalent air flow; the capacitors represent lung volume.

Using equivalent circuit and the one-order linear model, this simulation can be realized: according to the experiment measured the airway resistance and air flow parameters, calculated: the changes of air flow rate when the change in pressure, the pressure changes in lungs with the air flow changes, and the changes of respiratory effects caused by the change of parameters.

4.3 Result Contrast

The research group respectively to simulation for the “Heimlich Maneuver” group and the "Inverted Shock Maneuver" group to observe the process (omitted), the different pressure changes in the body after emergency operation method, Table1 shows the result of the “Heimlich Maneuver” group, Table2 shows the result of the "Inverted Shock Maneuver" group. The contrast results are as follows:

Table 1. Airway Pressure Results by Simulation Used the “Heimlich Maneuver" Method ($\bar{X}$±S)

Observing Index	Laryngopharynx	Tracheal carina
Pressure (cmH_2o)	26.3±1.5	23.7±3.2

Table 2. Airway Pressure Results by Simulation Used the “Inverted Shock Maneuver” Method ($\bar{X}$±S)

Observing Index	Laryngopharynx	Tracheal carina
Pressure (cmH_2o)	39.8±2.1	36.0±1.6

5. Conclusion

According to the simulation and animal experiments that have been implemented by now, we come to the observed results as follows:

The new first aid methods "Inverted Shock Maneuver" emergency procedure can exert a better role in the discharge of the foreign bodies that exist in the respiratory tracts than the traditional "Heimlich Maneuver" emergency procedure.

The new first aid methods "Inverted Shock Maneuver" emergency procedure can increase aerodynamics effects in the respiratory tracts more rapidly and stronger than used the traditional "Heimlich Maneuver" emergency procedure.

The Inverted Shock Maneuver emergency procedure can implement a timely first aid and also can prevent the residual sequelae of the consequences completely.

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