Design of a Pneumatic Device for Intussusception Reduction in Children

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Citation

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Abstract

Intussusception is an obstructive illness where a segment of the intestine gets into another segment of a neighboring one. Usually, it occurs within the first two years of life. In Venezuela, the most common way of resolving this pathology is through surgery which, although effective, represents a greater risk to the child. There are other less invasive reduction techniques such as air, barium and saline solution enemas. The pneumatic device which is used to reduce the intussusception is made with a sphignomanometer connected to a Foley's catheter. For this reason, this study pursued the following objectives: To assess the actual equipment for pneumatic reduction, and to propose modifications to such equipment. The methodology used was developed in two stages. The first one consisted of a need analysis of the actual device, and the second one of the proposed modifications to the pneumatic equipment. Some of the proposed modifications included the use of a pedal for insufflating air, digital reading of air pressure values, and adding a security air exhaust valve, calibrated at 120mmHg. All these modifications were aimed at facilitating patient manipulation and minimizing possible complications. Finally, it was concluded that: 1) The digital pressure messure is more reliable than the aerobic manometer. 2) Operating the device with the foot, facilitates it uses. 3) It is important to introduce the security valve calibrated to 120mmHg. 4) Cosider that the application of this model would benefits the patients and the public health. 5) The pneumatic reduction technique has many advantages over the surgical one. Recommendations: The incorporation of the modifications proposed in this study to the conventional equipment for pneumatic reduction, and to test the proposed equipment in order to assess its effectiveness on both experimental animals and human subjects.

INTRODUCTION

Intussusception is the main cause of intestinal obstruction in infants; it occurs during the first two years of life. In Venezuela, the most frequent method of resolution of this pathology is by surgery which, although effective, poses a greater risk to the child. There are other less invasive methods for resolving intussusception such as pneumatic reduction. In this study we propose some modifications to the currently used equipment with the purpose of encouraging the use of this technique as the first-choice method for the resolution of the above mentioned pathology.

STATING THE PROBLEM

The use of endorectal reduction is universally accepted as the first-choice treatment for intussusception, which can be carried out in various ways:

- Radioscopy or Ulthrasonography-guided air enema.
- Rasdioscopy-guided barium enema
- Saline solution or water enema through echographic visualization.

Each one of these procedures bears advantages and drawbacks. But, in any case, the percentage of perforations during the procedure is less than 1% ([13]). When the reduction fails or perforation occurs, surgical treatment is required.

In Venezuela, most patients with this pathology are treated with surgery ([12]). However, in other countries, such as in the Asian ones and in the United States, treatment is aimed at the reduction of the invaginated segment with as little aggressiveness as possible.

The first choice treatment is an enema (with air, saline solution, or barium), and monitoring of the reduction by echography which tends to resolve the problem in 85 to 90% of the children ([7]). Therefore, the rate of success is above 95%. When the reduction has not been complete or this technique is not available, surgical treatment is required. In other words, surgery becomes an alternative only in those

cases where the other techniques have failed or in children whose poor general health makes the above mentioned radiologic techniques not recommended.

We think that the introduction of some modifications to the actual device, will facilitates and promote its uses.

GENERAL OBJECTIVES

- To evaluate the actual pneumatic device for the reduction of the intussusception in children.
- To propose some modifications to the actual device.

SPECIFIC OBJECTIVES

- To obtain a better accuracy in the lecture of the pressure meassures, using an invasive pressure transductor, showing a digital meassure.
- To propose the use of a foot air pump to introduce the air into the system.
- To propose a connection system of tubes that allowes to maintain the air pressure levels inside the system.
- To propose the use of a calibrated security valve (120mmHg) which allowes to take out all the air from the system on a proper and effective way.

JUSTIFICATION

- Intussuception is an Urgency.
- The pneumatic procedure shows >90% of effectivness.
- This tecnique has advantages for the patients.

METHODS AND RESULTS

Proposal for modifications to the pneumatic equipment for intussusception reduction in infants:

First, an assessment of the actual device which is use to resolve intussusception cases. Second a design of the modifications suggested for the pneumatic equipment was made. Then, the proposed modifications were carried out.

ASSESSMENT OF THE ACTUAL DEVICE:

Nowadays, the device which is use for the pneumatic reduction of the intussusception is made with a sphignomanometer connected to a Foley's catheter. It is important to say that this equipment is made in a non-standar way by the Doctors, just to function in order to intruduse air in to the patient rectum.

PROPOSAL

PNEUMATIC EQUIPMENT FOR INTUSSUSCEPTION REDUCTION IN INFANTS (PHOTO #1)

The system consists of an air insufflator SEVYLOR, USA Mini foot pump w/Universal valve fittings. Measurements: 27.5 cm long and 12.5 cm wide. The device works through foot action (photo 1). It has a plastic black hose 106.5 cm long, which is connected to a clear plastic hose 11.5 cm long, attached to a cooper Y fitting, which in turn is connected to an air exhaust valve, calibrated at 120 mmHg (photo 2), which is the maximum pressure of insufflation recommended for this pathology.

The copper Y fitting is connected to another clear plastic hose 200 cm long, which is attached to the manual one-way air exhaust valve (photo 3) connected to yet another hose 20 cm long to which a blue invasive pressure transducer is attached (photo 4). The latter receives energy from a power source consisting of 4 AA batteries connected in series (photo 5). The transducer is connected to a digital tester (Digital Multimeter) (photo 6), used to express pressure values given digitally by the transducer, thus providing a more accurate reading and absolute values of the pressure found in the system and, consequently, from inside the patient's intestines.

A plastic hose 200 cm long coming out from the transducer is connected to a Foley rubber catheter 14 Fr, with an inflatable balloon at the tip (like those used for urethral sounding), to be introduced through the patient's anus until the balloon reaches the rectum, in which place it must remain to be inflated and therefore fixed inside the rectum, thus avoiding the exit of air through the anus.

The connections used are properly sealed to prevent any air leakages through them, thus maintaining the levels of pressure introduced into the system.

The proposed system for measuring air pressure has some advantages over the conventional aerobic manometer currently used, since the latter carries the risk of a malfunctioning of the spring controlling the manometer's needle, which would render flawed values. Besides, it is easier for the operator to read digits instead of lines

indicating pressure values.

CALIBRATION

With the purpose of calibrating the equipment, a mercury manometer connected to the digital pressure transducer was fitted so as to allow measuring air pressure values simultaneously in mmHg and milivolts, which permits comparing the two equivalent values. Then, 10 pressure curves were drawn to obtain an average and apply linear regression to it in order to obtain an appropriate equation for converting mmHg into millivolts. It is already known that the regression coefficient is r=0.9997 (p<0.000000001); therefore, a very high statistical significance was obtained (p value), which means that pressure values in mmHg can be obtained with almost 100% certainty from values in mV.

Regretion equation: Pressure (mmHg) = (35,978 x mV) - 1,943

Figure 1

Table 1: Calibration Curves

mmHg	1	2	3	4	5	6	7	8	9	10	Promedio	Regresión
0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	**0,1**	1,65 mmHg
20	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	**0,6**	19,64 mmHg
30	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	**0,9**	30,43 mmHg
40	1,2	1,2	1,1	1,1	1,1	1,2	1,1	1,1	1,1	1,1	**1,13**	38,71 mmHg
50	1,5	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	**1,41**	48,78 mmHg
60	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	**1,7**	59,21 mmHg
70	2	2	2	2	2	2	2	2	2	2	**2**	70,01 mmHg
80	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,4	**2,31**	81,16 mmHg
90	2,6	2,6	2,5	2,6	2,5	2,5	2,5	2,6	2,6	2,6	**2,56**	90,16 mmHg
100	2,8	2,9	2,8	2,8	2,8	2,8	2,8	2,8	2,8	2,8	**2,81**	99,15 mmHg
110	3,1	3,2	3,1	3,1	3,1	3,2	3,2	3,1	3,1	3,1	**3,13**	110,66 mmHg
120	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	**3,4**	120,38 mmHg

Figure 2

Table 2: Convertion Table of Pressure from mmHg to mV

mV	mmHg
0,05	0
0,61	20
0,89	30
1,17	40
1,44	50
1,72	60
2,00	70
2,28	80
2,56	90
2,83	100
3,11	110
3,39	120

DESCRIPTION OF THE SYSTEM: (FIGURE #1)

1) Neumatic pedal. 2) Manual air one way valve. 3) Security valve calibrated to 120 mmHg (3.39mV). 4) Invasive pressure transductor. 5) Digital tester, which shows the pressure measure taken by the transductor. 6) Foley catheter. 7) 3 way connector and plastic tubes.

Figure 3

Figure 1: Plot of the device.

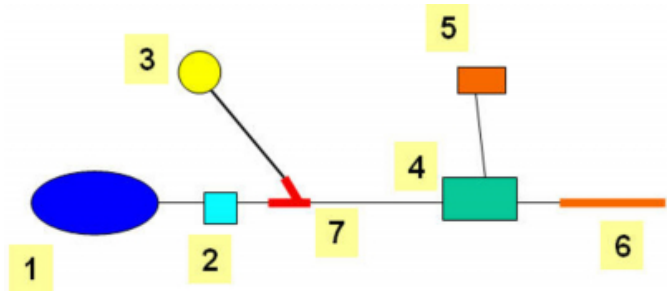

Figure 4

Photo 1

Figure 5

Photo 2

Figure 6

Photo 3

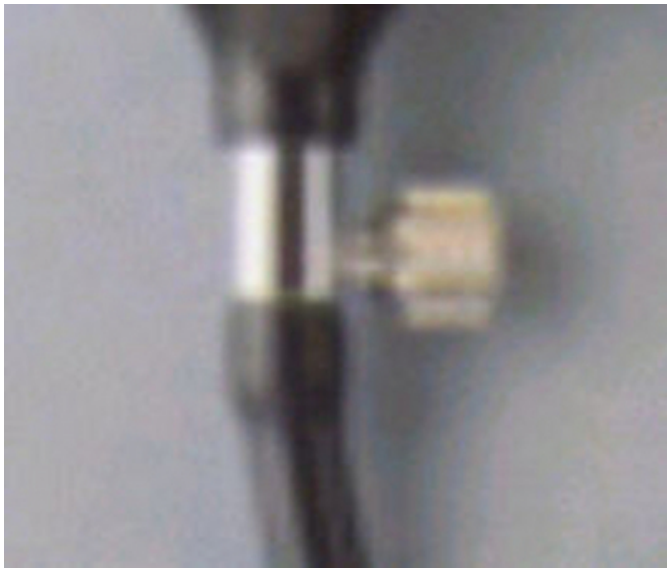

Figure 7

Photo 4

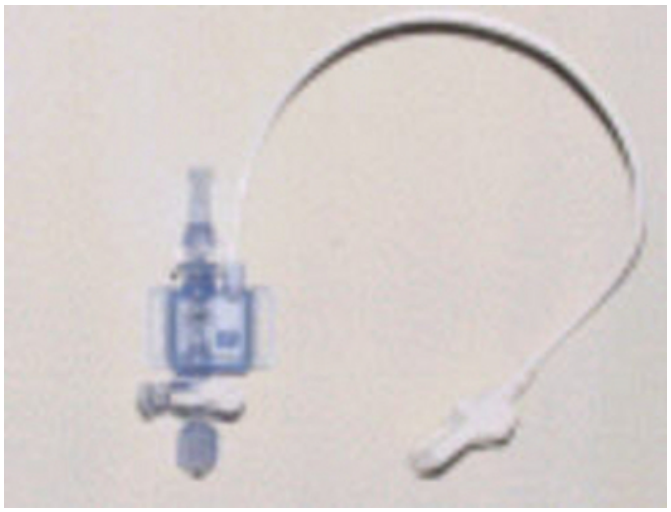

Figure 8

Photo 5

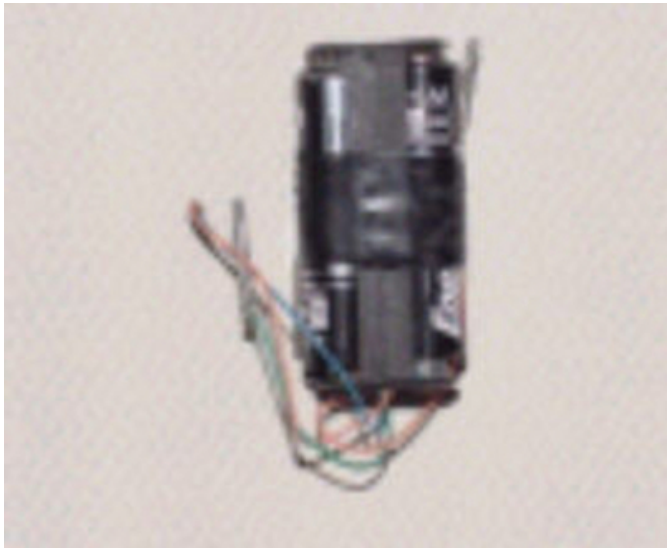

Figure 9

Photo 6

CONCLUSIONS

- The digital pressure messure is more reliable than the aerobic manometer.
- Operating the device with the foot, facilitates it uses.
- It is important to introduce the security valve calibrated to 120mmHg.
- Cosider that the application of this model would benefits the patients and the public health.

RECOMMENDATIONS

To test the proposed equipment in order to assess its effectiveness on both experimental animals and human subjects.

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