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Cybertherapy in Medicine – Experience at the Universidad Panamericana, IMSS and ISSSTE Mexico

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/52349>

1. Introduction

There are many reports of Virtual Reality analysis and clinical applications in Medicine since the end of the last century for many authors. In trauma head injuries [1], during chemotherapy in children [2], in burn wound care [3,4,5], lumbar puncture [6,], breast cancer [7], vein puncture [8], pain distraction [9,10,11,12], dental pain control [13], leg ulcer relief [14], night vision technology with robot control to treat bourn injuries using robot-like arm mounted VR goggles [15]. The first case reports related with VR and medical invasive procedures and surgery in hospitals was in 2004 with our group, beginning with upper gastrointestinal endoscopies and so on, until introduce VR in postoperative care unit of cardiac surgery [16,17].

Pain and anxiety in outpatients and inpatients is a regular symptom in hospitals. For pain are available medications and for anxiety also. Patients in; in-rooms, operating rooms and another different places, get treatments with medical and surgical procedures, and pain and anxiety are the meanly symptom. In this project we try to demonstrate that virtual reality is a complementary tool to reduce pain and anxiety in hospitals during medical procedures including surgical procedures. There are a lot reason and justifications to use VR in hospitals, as follows. *Neonatology* (0-28 days old) , there are newborns staying in unit cares since few days, weeks even months, growing without contact with the external world. The visit unit care is limited to parents in few hours a day. The psychological impact in growth and development in childhood is so hard, where neuro stimulation in a closed environment is a good alternative. In Infants (lower and higher infants) VR have been a good resource to reduce pain and anxiety in oncology. Hunter Hoffman has demonstrated in the benefits of

VR during medical rehabilitation in burned childhood. In *postoperative cardiac surgery unit care*, patients stay 3 days in different critical care units depending of their progress. In these units they stay under the influence of sedative drugs receiving treatments by vein catheters, gastric tube, etc. Their recovery is on beds with different degrees of limited position and the breathing relief is on bed also. In *ambulatory surgery* (General surgery, endoscopic surgery, urology, dermatology, Orthopedic, angiology, pediatric surgery, obstetrics), patients are awake, minutes, even hours awake during surgical procedures doing nothing in a same position on a surgical table. In the recovery they stay hours waiting for go home or to be hospitalized. Special group of ambulatory surgery, surgeon used night vision technology while patients navigate in VR environment. At the school of medicine from Universidad Panamericana we used night vision on animal models before the application on humans. *Gynecology and obstetrics*. Women during colposcopy are awake while gynecologist applies local anesthesia into the cervix to perform cervical conization with diathermal loop. The anxiety is present in a same gynecological position. *Gastrointestinal endoscopy*. Under local anesthesia, neurovegetative response is present during and after each upper gastrointestinal exploration of esophagus, stomach and duodenum. Patients present plenty of saliva associated with shortness of. *Labor Room*. Pregnant patients without complications expected hours to complete cervical dilation in labor room to go into delivery room or operating room. During uterus contractions they increase their respiratory rate. *Pediatric*. Scholar children stay on bed many days in recovery. In their stay they distract with games and in some times with a TV only. *Epidural and Spinal block in anesthesia*. This is a relative fast procedure compared with the previous groups where patient in the fetal position they expect catheter installation in their back, place where they can't see anything and anxiety is present despite local infiltration.

2. Methodology

The conditions to perform the following project are. Consent informed, full consciousness; agree to participate in the project; completeness vision, controlled cardiovascular and respiratory disease. Patients were affiliate at Instituto Mexicano del Seguro Social (IMSS) and Instituto de Seguridad y Servicios Sociales para los Trabajadores del Estado, (ISSSTE). In case of newborns, parents signed consent informed.

Technique. Before each procedure, nurse measured blood pressure, heart rate, breath rate (In the case of patients in unit cares, we considered arterial blood gases). Physician asks patients about his-her feelings (Anxiety) in a scale of 0 to 10 (where 0 is no pain and 10 is high pain). Physician installed the following equipment also: Laptop with 3 virtual scenarios (Enchanted forest, cliff final, icy city see figure 2) and connected to a vision goggles eMagin. When we used smart phones (Nokia N95 and iPhone G3) and PSP2 we used a mp3 video with a green valley scenario connected to goggles. Once set up the equipment, it was installed in the patient's head. Physician begins the procedure and in the middle of the procedure, nurse measured vital signs again and physician repeats the same question about the feelings (Anxiety and pain). Head Mounted display is removed of the head's patient at

the end of each procedure and 15 minutes after, nurse made the third measure of vital signs and physician asks the feelings of the patient again. In the case of Night Vision Goggles (NV) for ambulatory surgery for total darkness was necessary to perform open surgery on rabbits at the school of Medicine at the Universidad Panamericana in 9 rabbits under general anesthesia before to make ambulatory surgeries on humans. NV equipment needs a scrub nurse to hold all equipment on the head of surgeon and first assistant after dressing with sterile clothing. Cables were connected beside the surgical table. Diagnosis of surgery group: big lipomas on head, arms, legs or abdomen, non complicated inguinal and umbilical hernias. Complicated and non complicated postoperative hernias in the abdominal wall. For Laparoscopic group: non acute cholecystitis, and inguinal hernias. With night vision technology group: big lipomas on arms, legs and non complicated inguinal hernia. Diagnosis for postoperative care unit of cardiac surgery: aortic and mitral valves rechange and coronary revascularization. Colposcopy group: cervicitis and premalignant lesions in cervix. Neonatology group: premature newborns in recovery with more than 5 days to 2 months of hospitalizations with multiple diagnosis such as necrotizing enterocolitis, sepsis, respiratory disorders. In the kidney transplantation only one patient in the recovery used VR. In obstetrics, patients with 48 weeks of pregnant with 5 to 10 of cervical dilation participate with normal fetus in labor room where epidural or spinal block were installed and we follow the same patients to the delivery room and to the operating rooms. In the group of endoscopy, diagnosis was hiatal hernia, peptic disease and colon disorder.

3. Results

The comparative measure of pain were made before, during and after each procedure in all groups using Virtual Reality and the control group, except in patients without any medical procedure such as the group of care unit of cardiac surgery and neonatology. The statistical method to measure pain used was the mean into the scale of 0 to 10 (Cero is no pain and 10 is high level of pain). We present statistical results in the 3 representative groups where pain and anxiety are high such as colposcopy (see table 3), ambulatory surgery (see table 4) and postoperative care unit of cardiac surgery (See table 5). With the results of these groups we can appreciate the possibilities to use this technique in another groups into the hospitals because we have been tested VR in a group seriously ill in critical care units in cardiac surgery and manipulations of tissues including abdominal cavity in ambulatory surgery group. In table 1 we measured mean pain (see figure 1) between before to during the procedure and between before to after (see table 1). In the colposcopy group that used VR the mean pain before the procedure was 7.5 and during was 5.35 with a difference of 2.15 that correspond of 28.66 % of reduction of pain. In the group of colposcopy that didn't use VR the mean pain before was 6.43 and during 6.78 with an increase and difference of 0.35 that correspond of 5.44 % of increasing of pain, in the same group considering mean pain before of 6.43 and 4.83 after, the difference was 1.6 that correspond of 24.88 % of reduction of pain. In all groups we demonstrated an important reduction of pain using VR during medical or surgical procedures (see table 2). In care unit of cardiac surgery group the mean

pain before were 8 and after 30 was 3.64 with a difference of 4.36 that correspond to 54.5% of reduction of pain-anxiety (See table 2). In the group of surgery there were a mean of pain before of 5.7 and during the procedure 3.93 with a difference of 1.8 that correspond of 31.41 % of reduction on pain. Considering the mean pain before of 5.73 and 2.09 after, there is a difference of 3.64 that correspond to 63 % of reduction of pain. In the group of surgery that didn't use VR the pain mean were 5.57 before and during 5.19 with a difference of 0.48 that correspond to 6.8% of reduction, and considering the mean pain before of 5.57 and 3.52 after there is a difference of 2.05 that correspond to 36.80 % of reduction of pain. With these results we can appreciate the impact of distraction of VR to reduce anxiety and subsequently visceral and somatic pain in the case of surgery with regional anesthesia well placed.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n a_i = \frac{a_1 + a_2 + \dots + a_n}{n}$$

Figure 1. Mean equation to obtain results

MEAN of pain and anxiety	Colposcopy with HMD	Colposcopy no HMD	Critical care unit of cardiac surgery	Ambulatory surgery. with HMD	Ambulatory surgery. No HMD
Before	7.5	6.43	8	5.73	5.57
During	5.35	6.78		3.93	5.19
After	2.7	4.83	3.64	2.09	3.52

Table 1. Comparative measure of mean pain before, during and after each procedure in 3 representative groups. Pain scale used 0-10. (0 means no pain and 10 high pain).

% of pain and anxiety Reduction	Colposcopy with HMD	Colposcopy no HMD	Critical care unit of cardiac surgery	Ambulatory surgery. with HMD	Ambulatory surgery. No HMD
Before - during	28.66 %	5.44 %	54.5 %	31.41 %	6.8 %
Before - after	64 %	24.88 %		63 %	36.80 %

Table 2. Pain and anxiety percentage reduction, between before and during procedures. Pain scale used 0-10. (0 means no pain and 10 higher pain).

As a result of patient selection, we suggest the following general criteria to use VR in Medicine: 1.- Patients with voluntary participation, and signed authorization with written consent informed, (Patients under 18 years of age need written informed consent from parents), 2.- Medical control of cardiovascular, respiratory and neurological diseases, and 3.- full consciousness. (See figures 2 to 12)

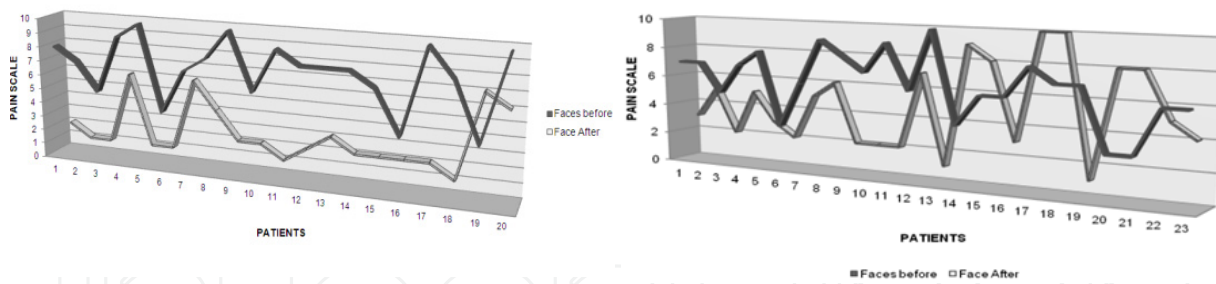


Table 3. Colposcopy. Group with VR (left) and control group (right)

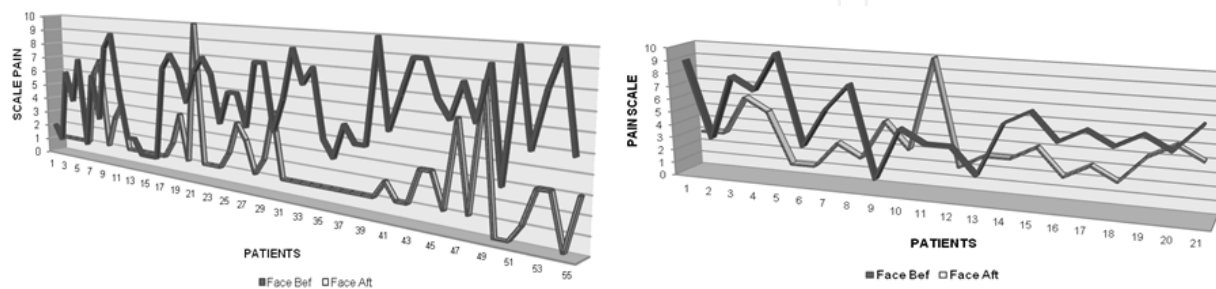


Table 4. Ambulatory surgery. Group with VR (left) and control group (right)

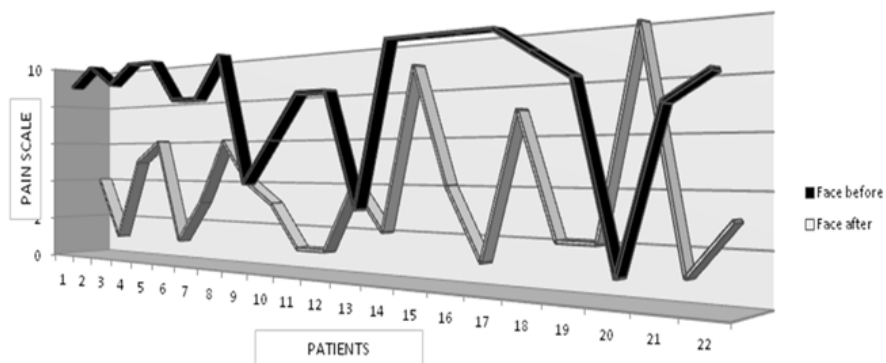


Table 5. Postoperative Care Unit of cardiac surgery

Medical complications. 2 patients of 22 in care unit of cardiac surgery group presented cardiac arrhythmias during the virtual navigation due to the slow effort on the bed, the treatment was the immediately disruption of VR exposure with total recovery. In ambulatory surgery group with local anesthesia, 2 patients presented nausea and vertigoes using VR and after 30 minutes patients become tired to carry goggles on their heads in the same position, for this reason we used a projector to display a screen in the roof of the operating room. In the subgroup of endoscopic surgery under regional anesthesia, 3 patients of 5, presented chest pain secondary of neumoperitoneum and it was necessary convert regional anesthesia to general (For this reason we don't suggest VR for endoscopic surgery under regional anesthesia). (See table 6).

Area	Cases	Complications
Care unit of cardiac surgery	Care Unit	2 patients presented arrhythmias.
Surgery	General Surgery	2 patients presented nausea and vertigoes, another one presented pain in peritoneum manipulation. 3 patients presented chest pain and difficulty breathing
	Endoscopic surgery	None
	Urology	None
	Angiology	None
	Dermatology	None
	Orthopedic	None
	Angiology	None
	Pediatric	
	Obstetric	
Anesthesia	Epidural/spinal block	None
Obstetric	Labour room	None
	Childbirth room	None
Endoscopy	Upper Endoscopy	None
	Colonoscopy	None

Table 6. Complications

Technical limitations. In ambulatory surgery, patients need to move their hands to get more distraction; but they hands tied to the table to avoid contamination and in the other hand they become tired with the goggles on their heads and after 45 minutes they prefer change the projection of the scenario to the roof of the operating room. With NV we found limitation for surgeon's motions for the cables connected to the wall beside the table one meter away. We had distorted vision for the glasses used, and the vision was in black and white color. The surgical time was small longer than conventional surgical time. In neonatology group, newborns present 5 to 8 seconds of attention for VR. It was difficult to evaluate the benefits of this technology, this is the reason we don't present statistical results. We suggest using another kind of device of VR to interact with these patients who have limited vision.

4. Conclusions

We found differences results according with age, gender, procedures, culture, origin of regions, diagnosis, prognosis, but in all groups we found reduction of pain and anxiety, one more than others, except the subgroup of endoscopic surgery, the only one we don't suggest use VR. . The group that enjoyed better the virtual scenarios was patients between 5 to 14

years of age in pediatric group. The older patients demonstrated curiosity of new technology that had in their hands.

There where patients exposed with Virtual Reality in different conditions like age, sex, medical procedures and different physicians but all results show us reduction of anxiety and pain. The answers were different in each group because pathways of pain involved are two, somatic and visceral. Tissues and organs manipulated were different, for instance: Skin, fat, muscles, fascias, peritoneum, cervix, uterus, peritoneum, spine's dura, ligaments, small and medium vessels, gallbladder, omentum, visceral peritoneum, parietal peritoneum, esophagus, stomach and colon's mucous. On the other hand, Patient's psyche played an important role for anxiety and pain. All patients required medications for local and regional anesthesia such as analgesics, sedatives, in different dosages. The high level of pain we saw in all groups of patients was those who underwent endoscopic surgery.

In the beginning of our experience, we used a Spider HMD game to distract patients under upper GI endoscopy in 2004. Thanks of these results we improved the devices introducing Virtual reality scenarios and a HMD developed by Brenda and Mark Wiederhold from the Virtual Reality Medical center from San Diego CA. Clinical applications were done at the Instituto de Seguridad y Servicios Sociales para los Trabajadores del Estado I.S.S.S.T.E. and at the Instituto Mexicano del Seguro Social IMSS, Public Health Centers in Mexico City. There were big and small groups because the results from critical care unit of cardiac surgery and ambulatory surgery allow us to conclude the usefulness of virtual reality to reduce pain and anxiety in inpatients without minimal complications and permit us to limit virtual applications in all areas of Medicine. If patients in critical care unit presented no more than 2 complications and in surgery we consider absolutely contraindicated in endoscopic surgery is obvious to use virtual reality without major risk in the rest of areas of medicine if we follow the absolute indications.

Virtual reality is a not invasive method, easy to use, easy to install and easy to carry and each day new generations of technology are lighter, smaller such as smartphones, PSP 2, iPads that permit more interaction with users using friendly feedbacks such as tracking (Kinect), 3D images permit more immersion with Interactive screens that could be considered in future works because U screens, virtual cubes and cave could be an option for patients because these screens have demonstrated the utility in rehabilitation for the big space for body motions and for the stereoscopic immersion.

The best advantage for the healthcare institutions we found in the group for ambulatory surgery was to reduce the half of dosage of medication of fentanyl, and midazolam, and in many cases we avoid totally these medications in the intraoperative. This advantage represent an important saving for institutions always considering and appropriate selection of patients with absence of cardiovascular and respiratory disease that could permit physician works without concerns during procedures. With these results we can give the following advantages as: reduction of medication (Analgesic and in several cases, drugs to reduce anxiety as fentanyl and mydazolam), bed days and specially increase the wellbeing of patients. There were small groups of one or two patients that should increase the number

of cases to get reliable results, however their results are a clear indicator of benefits of virtual reality. We didn't consider more areas of medicine, but we involve representative as surgical and clinical areas and both sex, males and females and different ages, newborns and adults. Technology developments permit use small device such as mobile phones to connect to head mounted display instead of laptops; they facilitate the handling of the virtual scenarios. 3D scenarios will permit more immersion in patients (see table 7). Display scenario on the wall is an option for navigations instead to use HMD which can be tiring for patients in prolonged time. Virtual reality is useful in hospital and we consider that in the future, virtual rooms could be integrated inside services, operating rooms, and waiting rooms.

Medicine Apps	Interface used	Virtual scenario	Area	Cases	Control group	Patients participants
Ambulatory Surgery	Laptop	Enchanted forest	Surgery	53	31	84
Ambulatory Surgery	Laptop & Night vision	Enchanted forest	Surgery	5	0	5
Ambulatory Surgery	Nokia	Green valley video	Surgery	23	0	23
Ambulatory Surgery	PSP2	Green valley video	Surgery	24	0	24
Ambulatory Surgery	X BOX	Video	Surgery	2	0	2
Ambulatory Surgery	iPhone G3	Green valley video	Surgery	2	0	2
Pediatric surgery	PSP2	Green valley video	Pediatric surgery	1	0	1
Recovery surgery	Laptop	Enchanted forest	Kidney transplantation	1	0	1
Surgical cleaning	Laptop	Enchanted forest	Surgery-Infectology	11	10	21
Epidural blockage	Laptop	Enchanted forest	Anesthesia	4	3	7
Labor room	Laptop	Enchanted forest	Obstetric			
Cesarean	Laptop	Enchanted forest	Obstetric	1	1	2
Delivery Room	Laptop	Enchanted forest	Obstetric	1	2	3
Neonatology Unit care	Laptop	Enchanted forest	Neonatology	5	0	5

Medicine Apps	Interface used	Virtual scenario	Area	Cases	Control group	Patients participants
Colposcopy	Laptop	Enchanted forest	Gynecology	20	23	43
Upper GI Endoscopy	Spider HMD Game	Spider game	Endoscopy	200	200	400
Colonoscopy	Laptop	Enchanted forest	Endoscopy	3	0	3
Unit care	Laptop	Enchanted forest	Cardiac surgery	20	22	42
TOTAL PATIENTS				376	292	668

Table 7. Interfaces and VR scenarios used in each group as well as the total patients participants in the groups studied and controls.

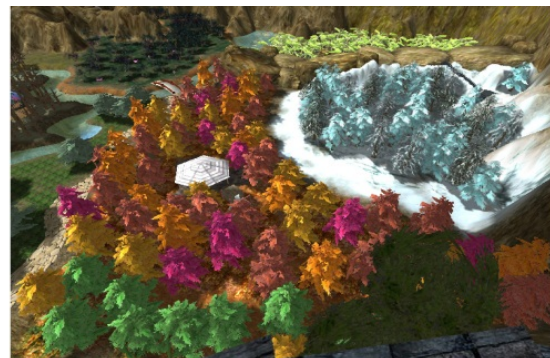


Figure 2. Enchanted forest scenario used in the majority of procedures.



Figure 3. Upper Gastrointestinal Endoscopy.

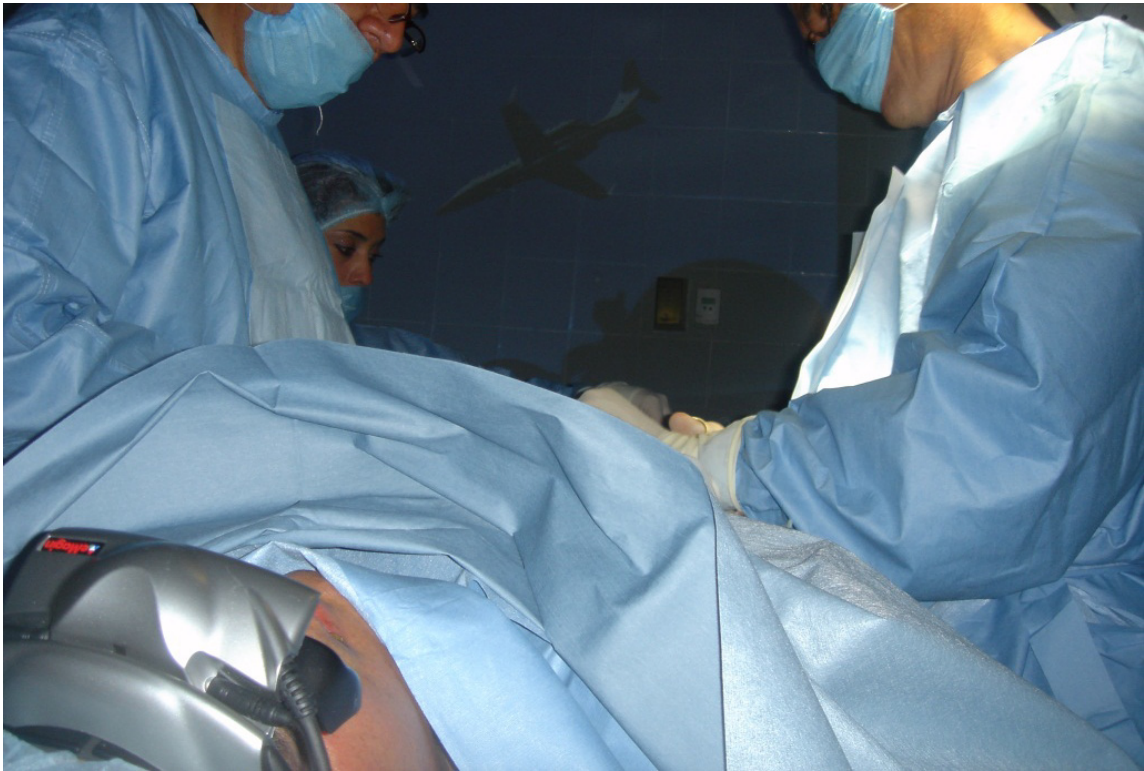


Figure 4. Ambulatory surgery with regional anesthesia



Figure 5. Endoscopic surgery with regional anesthesia



Figure 6. Care unit of cardiac surgery



Figure 7. Labor room



Figure 8. Anesthesia. Epidural/ spinal block



Figure 9. Delivery room



Figure 10. Recovery room. Post cesarean surgery



Figure 11. Neonatology care unit

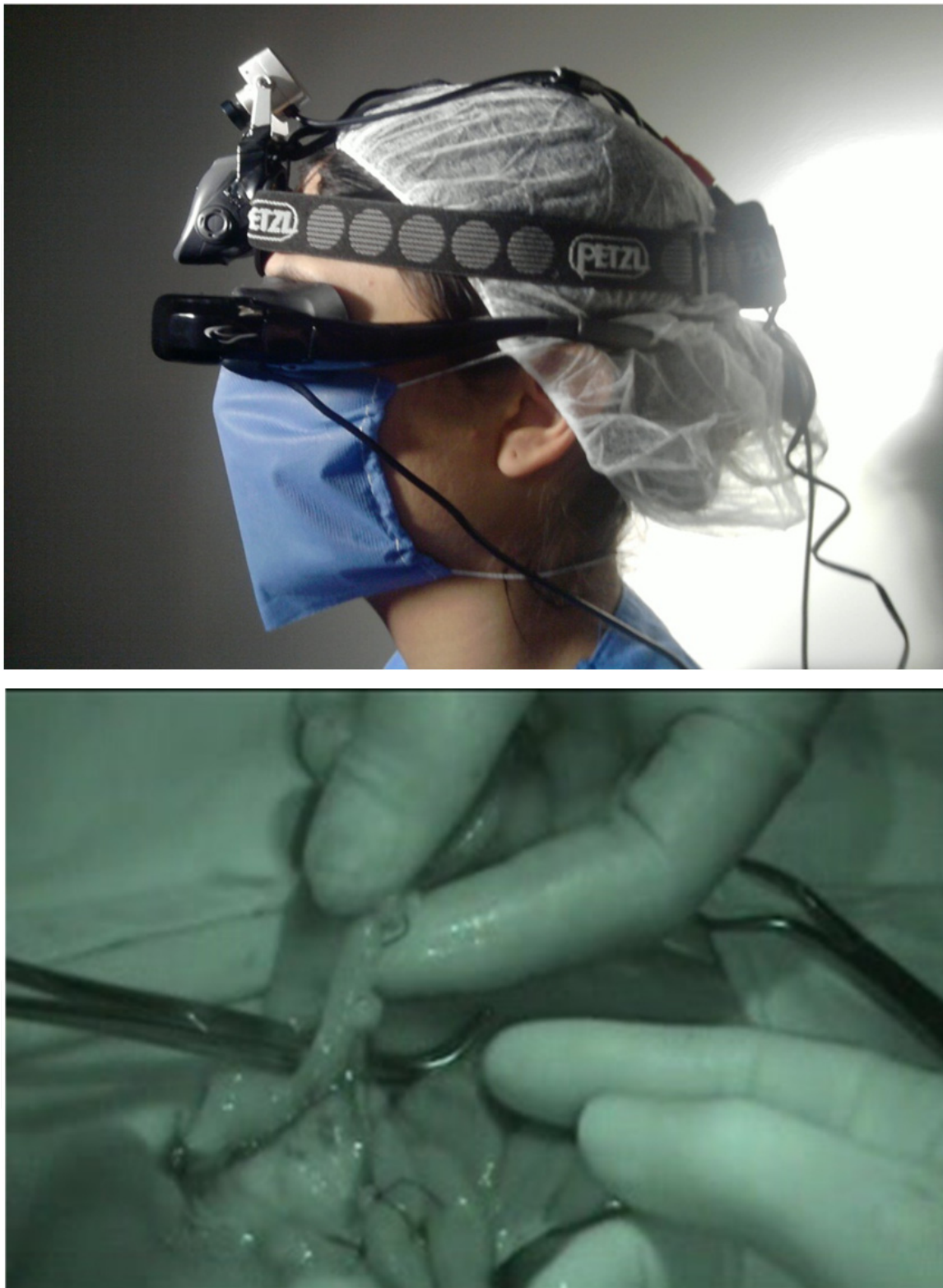


Figure 12. Night vision equipment (above). Appendectomy with night vision goggles. School of Medicine, Universidad Panamericana (Below)

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