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Research

Mobile Hysteroscopy

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Abstract

Introduction: The purpose of this study was to evaluate the feasibility and clinical outcome of a new setup for diagnostic hysteroscopy using mobile technology.

Materials and Methods: A total of 15 women with indications of diagnostic hysteroscopy were examined according to the new setup using smartphone and portable led light sources and the standard hysteroscopic setup. The image quality as far as it concerns the ability to end up with a correct diagnosis was assessed. The total cost of the two setups was also compared.

Results: The image reviews of the experts revealed no difference in the diagnostic adequacy of the two setups. All 30 reviews, regardless of device used for image capture were conclusive for the diagnosis. Moreover, the total price difference between the two devices was 47,101€.

Conclusions: With the new system high quality images may be captured and it has the advantage of minimal equipment and easy set up. Moreover, the combination of portability and low cost could widespread advanced endoscopic technology in almost every health care facility.

Keywords: office hysteroscopy; portable hysteroscope; smartphone; iphone; health care costs; medical image

Introduction

Hysteroscopic inspection of the uterine cavity is important in the work up towards diagnosis of intrauterine abnormalities. Modern diagnostic hysteroscopy began in the 1970s, when the uterine cavity was seen clearly with the use of distension media[1]. Because of advances in endoscopy that include smaller endoscopes light emitting diodes (LED) displays and camera miniaturization, these procedures have largely moved out of the hospital and into the office[2]. Moreover, the development of "no touch" hysteroscopy (vaginoscopic approach to hysteroscopy), which is performed without speculum and tenaculum, has contributed towards this direction[3]. On the other hand as more these technologic advances are applied to the clinical setting, the cost of the endoscopes and their accessories (light source, cables, HD cameras and monitors) is continuously increasing, in a way that render them inaccessible for many health care facilities.

It's not that long ago, just in the first half on the 1990s, when mobile phones were brand new, the size of bricks, very expensive, and all they could do was making phone calls. We're in the era of the smartphone these days, a device that can function as a computer, a digital camera, an entertainment and working center. The worldwide accessibility of smartphones with more than 2,1 billion users in

2016 makes the utility of this technology promising in medicine[4].

Mobile technology has been already used in the healthcare setting to facilitate fiberoptic intubation, endoscopic urological evaluation, and ventricular catheter placement[5,6].

Our Department has developed a portable hysteroscopy setup with the utilization of mobile smartphone iPhone 6s, a specially designed adaptor and a portable light source. The mobile phone is transformed this way into a completely mobile hysteroscopic viewing system and the whole setup portable.

Material and methods

Portable setup

In our study we used 2 different hysteroscopic setups. A standard one using a rigid 30 degrees hysteroscope coupled with an endoscopic camera (Karl Storz camera head), a video system/receiver monitor and a standard high powered xenon light source. The alternate was the same hysteroscope coupled via a commercially available adaptor with an iPhone 6s (Apple Inc., Cupertino, CA) in camera mode. A portable light source has been used to make the system transportable. In addition to the smartphone display we used Apple TV and Airplay to wirelessly stream a mirrored display of the endoscopic image to a larger display. The smartphone contained no cellphone provider card and we only used its multimedia capabilities.

Hysteroscopic technique

In our Department we perform diagnostic hysteroscopy with the Vaginoscopic or 'no touch' technique. Initially we perform a bimanual pelvic examination with the patient in the dorsal lithotomy position and the vaginal introitus is prepared with normal saline. Without using a speculum, the rigid, narrow caliber (2,9 mm) hysteroscope is introduced into the vaginal introitus. We infuse normal saline at a pressure of 150 mmHg and we visualize the cervix and direct the hysteroscope through the cervical canal into the uterine cavity. No anesthesia is used this way and there is a significant reduction in operative pain. Before proceeding to hysteroscopy every patient underwent vaginal ultrasonography for the examination of uterine anatomy.

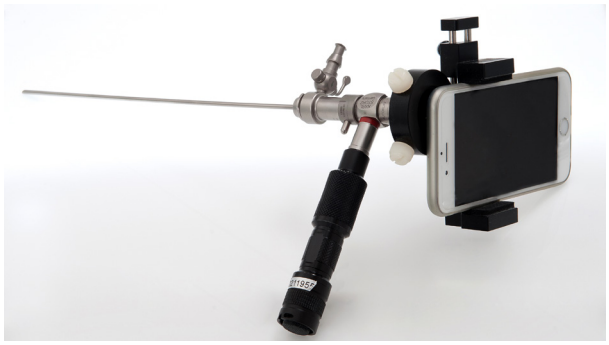

Figure 1: Portable hysteroscopic setup. The rigid hysteroscope coupled with iPhone 6s and portable LED light source

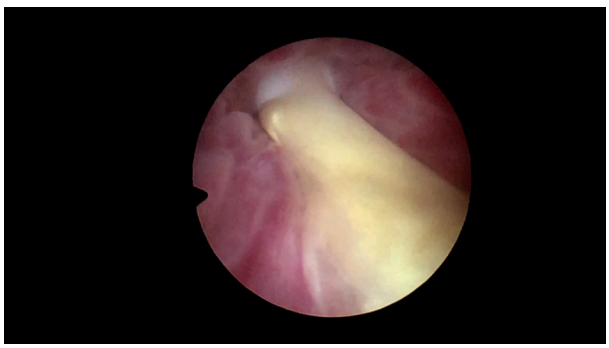

Figure 2: IUD inside endometrial cavity (mobile image)

Patient selection

Our study included 15 patients with benign gynecologic entities having the indication for diagnostic hysteroscopy. Each one of the patients underwent hysteroscopy with both setups and the images were collected and reviewed from 2 independent experts on the field. The patients have signed a written informed consent form and agreed to participate in this study. The study was approved by the local ethics committee. Each image has been rated from the evaluators based on Lickert analog scale (from 1 very poor quality to 5 very good quality) concerning the quality overall, the colors, the brightness and the resolution. The evaluators were blinded as to which set was from either device. Moreover the experts were questioned if any sin-

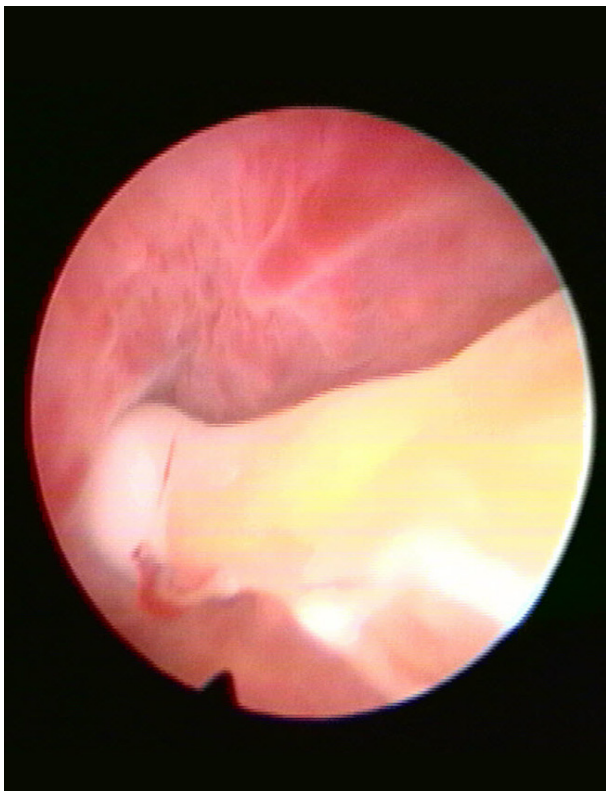

Figure 3: IUD inside endometrial cavity (standard image)

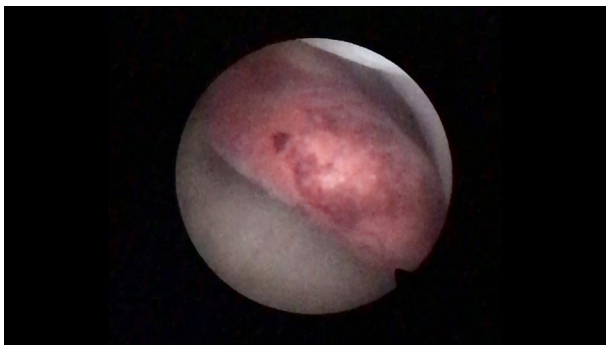

Figure 4: Endometrial polyp (mobile image)

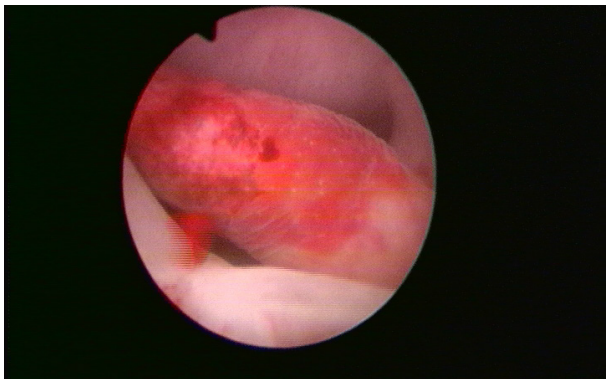

Figure 5: Endometrial polyp (standard image)

gle's image quality was adequate in order to make the diagnosis.

Results

When queried about the efficacy of the two setups concerning the performance of no touch diagnostic hysteroscopy, the experts noted that both devices were convenient. Although no touch requires good image quality in order to perform the vaginoscopy and locate the cervix, operators stated that they faced no problems in this part of the procedure with the new setup.

The image reviews of the experts revealed no difference in the diagnostic adequacy of the two setups. All 30 reviews, regardless of device used for image capture were conclusive for the diagnosis.

The cost of the standard medical camera system was 15,000€ and 18,000€ the monitor and video system. Moreover xenon light source's cost is 15,000€; total cost of the standard setup is 48,000€. On the other hand iPhone 6s costs 699€ and 80€ the adaptor used. Another 120€ is the cost of the portable light source. Finally our new setup has a total cost of 899€. The total price difference between the two setups is 47,101€.

Discussion

Diagnostic hysteroscopy is a commonly performed gynecologic procedure to evaluate the endometrial cavity. Since the late 1980's J. Hamou developed an endoscope by which it was possible to light the uterine cavity, allowing to evaluate the endocervical canal, endometrial cavity, and tubal ostia[7]. Advances in video technology and fiber optic hysteroscope was the way to reduce the diameter of the instrument making the procedure more patient friendly and widespread it among gynecologists. Each step forward has been laden with a marked increase in price. Our report introduces for a first time a portable hysteroscopic set up taking advantage of the innovation of the mobile technology concerning video recording, image capture and

data storage and sharing; simultaneously we have an impressive cost reduction compared to the conventional set up.

At the present study hysteroscopic image resolution and acquisition with the portable set up was equivalent to the existing standard surgical camera system. The reviews from the experts concluded that both systems were comparable for diagnostic purposes. The major advantages of the mobile technology are one-touch video recording and image capturing, real time monitoring, image sharing and data storage[8]. Smartphones are easily accessible around the world with a constantly reducing price and they provide to the hysterscopic set up portability.

A simple comparison of the costs of the 2 systems may lead us to the conclusion that the portable device can be a useful alternate to the standard setup, especially in hospitals with minor resources. The cost of the iPhone and the adaptor we used together with the portable light source was 899€ in total. On the other hand the surgical camera, the video system and the xenon light source we use in our hospital can cost up to 48,000€. If we choose to use older iPhone devices (5 or 5s) then the cost of the portable setup can be reduced down to 550E. That means that as far as it concerns the cost, more than 80 portable devices could be purchased for the price of one standard hysterocopic tower. This fact is very important especially for countries like Greece that in the era of economic crisis have a strict financial policy and permits to the hospitals to provide high quality healthcare service with minimal cost.

In addition, our system's portability is another major progress. The small smartphone device has replaced the camera, the video recorder, the monitor and the cables. Moreover as a light source we use a small lightweight LED wand with rechargeable AA battery and push button activation instead of the standard xenon light source. All these devices need space and weight a lot, a fact that constitutes them at least cumbersome. In most circumstances the setup is immobilized in a specific hospital's operating room or outpatient office and the patient has to be transferred there in order to undergo the examination. The reduction in the total volume of the set up, with parts that could fit into a handbag is of clinical significance. Diagnostic hysteroscopy could be performed in the emergency department, at the hospital floor, even in the private medical office.

The combination of low cost and portability could make hysteroscopy a more easily performed operation and widespread its use for the diagnosis of gynecologic pathologic entities. Therefore the procedure could move to the outpatient office and replace saline infusion sonohysterography. This method has a few technical concerns that hysteroscopy could overcome. First, it sometimes it is difficult to thread the flexible catheter into place because of cervical stenosis, uterine position, or abnormal uterine contour[9]. The use of a speculum and tenaculum can cause unaffordable discomfort to the patient. In addition, sonohysterography presents a high false positive rate especially when performed after the 10th day of menstrual cycle (up to 27%) attributed to blood clots, intrauterine debris, mucus plugs, shearing of normal endometrium, thickened endometrial folds, and misidentified endometrial fragments[10]. In order to overcome poor visualization, high-end ultrasonic devices are used having a negative impact at the cost of the examination. Finally the major advantage of hysteroscopy is the direct visualization of the uterine pathology unlike sonohysterography that has indirect findings; therefore, a sonographer is needed to make the correct diagnosis in contrast with hysteroscopy that even a less experienced gynecologists could perform the examination[11]. For all these reasons, our setup that offers the opportunity to perform the procedure in a health care providers office, could render it preferable than sonohysterography.

Another benefit is that a secure Internet connection with full-motion video and wireless data transfer to almost any location in the world is achievable with the smartphone. Telemedicine programs could take advantage of this technology

and the new daily released applications. Specifically, information can be shared even real time during the procedure between colleagues, experts or students. This can promote advanced endoscopy in small medical offices in rural regions of Greece. There are already a few pilot projects of mobile endoscopic units and the new inexpensive set up could help to enlarge this vision[12-13]. Students may also benefit as interactive lessons of real time endoscopy could be made and resolve their inquiries at the time of the operation. Finally, hysteroscopists could have immediate experts feedback with a major advantage the health care quality of the patient.

Conclusions

Mobile adapted endoscopy equipment allows for point of care image capture and video sharing with an ease that has not been previously available. Our hysteroscopic set up is a low-cost video hysteroscopy system with minimal equipment that can capture video of sufficient quality for diagnosis. Systems unprecedented portability can contribute to hysteroscopy expansion in almost every medical office.

Conflict of interest

The authors declare that they have no conflict of interest.

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