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Review

Laparoscopy as a Diagnostic Tool in Bovine Reproduction: A Review

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ABSTRACT

Laparoscopy is a procedure of examining the abdominal cavity and its contents with an illuminated telescope. Diagnostic laparoscopy is at present being utilized on a large scale in humans as well as in animals and has led to considerable advances in the diagnosis and management of fertility. For exploration and evaluation of infertility, laparoscopy is considered an essential step and a standard procedure and offers an excellent way through direct visualization to clarify the hidden pathology. Laparoscopy is used as a gold standard method for quite a variety of gynecological conditions especially in humans. The present review was written to record the use of laparoscopy as a diagnostic tool especially in bovine reproduction.

INTRODUCTION

Laparoscopy:

Laparoscopy (Gr: *Laparo*-abdomen, *scopein*-to examine) is the procedure of examining the abdominal cavity and its contents. It requires insertion of a cannula through the abdominal wall, distension of the abdominal cavity with gas or air (pneumoperitoneum) and visualization and examination of the abdominal contents with an illuminated telescope. Explorative laparoscopy is currently being utilized on a large scale in humans as well as in animals especially in equines throughout the world and is considered safe and fast technique that can be performed under general or local anaesthesia. Laparoscopy has been used widely in medicine over 30 years and the first reported use of reflected light to examine the cervix was by the Arabian physician, Albukasim (936-1013 A.D). The next reports were in the early 1800s where Bozzini used a mirror, illuminated by a wax candle, to examine the urethra. Kelling[1] provided the first attempt at endoscopy of the peritoneal cavity, used sterile filtered oxygen for insufflations and a cystoscope to look at the peritoneal cavity of dogs. Later, Zollikofer[2] used carbon dioxide to obtain pneumoperitoneum, which reduced pain and thermal complications. The automatic insufflator developed by Semm[3] further improved the safety margin of laparoscopy and later inclusion of video computer chip allowed laparoscopy to become integrated into general surgery. Access into the abdomen is the one challenge of laparoscopy as major complications occur prior to commencement of the intended laparoscopy.[4,5] In 1974, Raoul Palmer of France popularized the use of Veress needle using CO_2 to induce pneumoperitoneum for laparoscopy and subsequently published on its safety in the first 250 patients.[6] Palmer emphasized that the creation of pneumoperitoneum remains a vital first step, and it is the one still associated with recognized complications. Thus, Dingfelder[7] was the first to publish on direct entry into the abdomen with a trocar and the suggested advantages of this method of entry are avoidance of complications (failed pneumoperitoneum, preperitoneal insufflations, intestinal insufflations or the more serious CO_2 embolism) associated with the use of Veress needle.[8] However, it is the least performed laparoscopic technique in clinical practice today.[9]

Laparoscopy has gained a leading role and appears to

be the gold standard method for a quiet wide range of gynaecologic procedures.[10] The development of laparoscopy has led to significant advances in the diagnosis and management of fertility to enhance animal production and is being used increasingly in the embryo transfer industry especially for species or age groups where it is not possible or easy to manipulate the reproductive tract per rectum during oocyte and embryo retrieval and during embryo transfer.[11] Laparoscopy is now considered an essential step and a standard procedure in the investigation and evaluation of infertile human females and offers an excellent means through direct visualization to elucidate the hidden pathology. Although use of laparoscopy as a diagnostic tool for infertility evaluation is presently frequent in equines[12,13] but its use in bovines for infertility assessment is very meagre.

Insufflation:

In order to perform laparoscopy, pneumoperitoneum is created to provide a space to work in and allow proper visualization of structures. Kelling[1] reported the observation of the abdominal cavity of dogs and humans through an air filled abdomen for the first time in 1902. This procedure named "coelioscopy" became a routine in humans in 1914.[14] Goetze[15] developed an automatic needle in 1918 in order to reduce the risk of a blind puncture of the abdomen and reported as ideal practice of initially establishing a pneumoperitoneum. Since the development of first automatic CO_2 gas insufflator in 1966, [3,16] the practice of creating and maintaining the pneumoperitoneum was universally adopted using such a device. Although at least 5 different gases or mixture of gases have been used to perform pneumoperitoneum, CO_2 is used almost exclusively. Such a gas is rapidly absorbed, excreted and does not support combustion. It is the most soluble in blood of all agents used for abdomen insufflations and is safer than oxygen, air and nitrous oxide (N_2O) in preventing gas embolism[17,18] although; there is no general agreement on the subject.[19,20] However, absorption of CO_2 into the blood contributes to hypercarbia, acidosis resulting into hypertension, tachycardia, cardiac arrhythmias, vasodilatation and myocardial depression.[21]

Although, different methods are used for creating pneumoperitoneum but the easiest way to maintain working space with a consistent intra-abdominal pressure is by use of an electronic CO_2 insufflator. Similarly, various insufflation cannulas have been used in laparoscopy and traditional Veress needle can be used for animals that have been placed in dorsal recumbency but are generally considered to be too short for the flank of large animals where standing laparoscopy is performed. The other problem with the Veress needle is that it has a very small diameter, which slows the flow of insufflation gas into the abdomen. Recently, more surgeons are choosing to perform an open, "Hasson" technique where a laparoscopic cannula with a blunt obturator is introduced into the peritoneal cavity. For standing flank laparoscopy, insufflation has also been achieved by small diameter chest tubes, mare urinary catheters and more recently laparoscopic cannulas with blunt obturators[22] and by direct trocar insertion using 6 mm trocar and cannula unit which was found better than Veress needle method.[23]

In man and animals, the recommended intraabdominal pressure during laparoscopy is 10-15 mmHg and pressures greater than 20 mmHg for prolonged periods can produce negative cardiovascular and respiratory effects and cause some reduction in blood supply to the serosa of intestinal tract.[24] However, in bovines for ovariectomy and for evaluation of genitalia through transabdominal laparoscopy, optimum intraabdominal pressure during laparoscopy was found 6-10 mmHg.[23,25]

Trans-abdominal Laparoscopy (TAL) Procedure:

Prior to laparoscopic examination, feed but not water is withheld for a variable period of 18-48 h[23,25,26] and cows are sedated with xylazine and local infiltration of portal sites is done with lignocaine (2%) before laparoscopy.[25-28] Sedation with xylazine is very useful for smooth examination especially in aggressive animals.[23,25] However, some animals sedated with xylazine get recumbent during the examination and are unable to stand.[23] Fasting facilitates laparoscopic examination of genital tract, reduces chances of rumen puncture when left flank approach is used and facilitates movement of laparoscope and instrument during examination. Both left flank and right flank approach can be used for laparoscopic examination of genital tract with minor limitations in both the approaches.[25,27,29,30] The left paralumbar approach presents the advantage that the rumen supports the parietal peritoneum firmly against the abdominal wall facilitating the puncture of this layer and the greater omentum does not affect visualization since it courses under the rumen.[23,31] However, in the right side, hindrance to the movement of laparoscope and instruments due to rumen especially when fasting time is shorter is absent. Further, there is no chance of rumen puncture on the right side but laparoscopic examination is hampered in few cases due to omento-serosa layer and mesentery on right side which has not been observed on left flank approach.[25] Further, right flank approach involves the risk of intestinal perforation[25] especially with instrument port as this port is made ventral to tubar coxae in lower flank region. However, Singh and Rawal[26] reported that laparoscopy was performed more easily though right paralumbar fossa approach than left paralumbar fossa as it was time consuming, disadvantageous for accidental puncturing of rumen and also provided less space to manipulate the laparoscope.

Laparoscopy entry techniques utilized for entry into the abdomen include Veress needle method using traditional Veress needle and direct trocar technique using 6 mm trocar cannula unit but the direct trocar technique has been found better alternative technique than the Veress needle method.[23] Further in direct entry technique, time required and initial steps for laparoscopic examination were reduced in comparison to Veress needle technique of insufflations.[32,33] The pneumoperitoneum is created by CO_2 gas using automatic insufflator and the intraabdominal insufflation pressure maintained during examination is around 6-10 mmHg. At this insufflation pressure, examination is done comfortably as higher pneumoperitoneum lead to straining and physical discomfort by the animal during examination.[24,25,34,35] Although, there are reports of laparoscopy at higher intraabdominal pressure[36,37] but it has

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been observed that the animal become restless and shows signs of colic when intraabdominal pressure is increased to 10 mmHg or above [23,25] The optimum site of laparoscopic port both in right and left flank approach is 8-10 cm cranial to the tip of tuber coxae and 6-8 cm ventral to the transverse processes of lumbar vertebrae at the junction of middle and caudal third flank. Similarly, the optimum site of the instrument port both in right and left flank approach is 18-20 cm ventral to the tip of tuber coxae and 2-3 cm cranial to that point.[23] However, in few laparoscopic examinations second instrument port both in right and left flank approach can be made at 10-12 cm ventral to the tip of tuber coxae and 4-6 cm cranial to that point. The optimal portal sites for laparoscope as well as instruments were determined by testing various locations and those described above were found optimum for examination of the genital tract in cattle as per author.[23] The CO_2 consumption for each laparoscopic examination is 45-80 litres with an average of 60 litres[23] which varied with the abdominal size and the duration of examination. However, the time required varied with the entry technique, size of abdomen and cooperation by the animal as time required is less in direct entry method, small sized animals and less aggressive animals.

New Techniques:

Recent advances in human laparoscopy are being evaluated in animal laparoscopy. Most notably is the evaluation of natural orifice transluminal endoscopic surgery (NOTES).[38] In this study, it was determined that abdominal exploration was adequate through either the left or right transvaginal approach. Structures that could be evaluated were the left kidney, spleen, nephrosplenic space, stomach, cecum, duodenum, left and right ovaries, diaphragm, caudal peritoneal reflection, and inconsistently the liver.

Use of Laparoscopy in Gynaecology:

Laparoscopy has been extensively used for the diagnosis and treatment of various reproductive disorders in human females[39,40] and rapidly advanced from being a diagnostic procedure to one used in fallopian tubal occlusion, for sterilization and eventually in the performance of numerous surgical procedures in all surgical disciplines for a variety of indications. Until recently, laparoscopy was the final diagnostic procedure of the female fertility exploration, as outlined by the American Fertility Society in 1992 and by the World Health Organization guidelines[41] and 89 percent of all reproductive endocrinologists in the USA routinely performed a laparoscopy in the diagnostic work-up of infertility[42] However, veterinary laparoscopy began much like the use of laparoscopy in the field of gynaecology in humans. Roberts[43] first reported endoscopic/laparoscopic examination of reproductive organs in sheep. Endoscopy was initially used for direct observation of the ovaries and uterus of the ewe by means of an illuminated endoscope, inserted through an abdominal cannula. Later, Witherspoon and Talbot[44] published 2 papers on the use of laparoscopy as a diagnostic tool to describe population events in the mare. Witherspoon et al.[45] reviewed the current uses of laparoscopy and recommended the use of either a rigid or flexible endoscope or dual trocar techniques to allow surgical manipulation. Wilson[46] published on the use of laparoscopy to evaluate the reproductive tract of mares using a single trocar technique and a laparoscope alone for diagnostics, or an operating laparoscope for biopsies or manipulations. Wilson and Madison[47] described the use of laparoscopy to diagnose the presence and location of abdominally retained testes.

Evaluation of Tubal Patency:

The oviduct has been regarded as an insignificant source of reduced fertility, primarily because of the inability to clinically evaluate either its structure or function and majority of information describing abnormalities of the oviduct is derived from post mortem dissections, flushings and histology. Because oviductal pathology is difficult to diagnose on routine transrectal palpation or ultrasonography, direct examination *via* flank or ventral midline laparotomy or laparoscopy is required. Recently, laparoscopic[13] placement of fluorescent beads within the oviduct has been used to evaluate patency using a less invasive, but more specific approach (i.e., differentiates left vs. right oviduct and assures correct placement of beads). Similarly, laparoscopic chromopertubation for evaluation of tubal patency through flank approach using methylene blue (2.5%) dye has been done in bovines.[48] Laparoscopy has been recently used for re-establishment of oviductal patency in infertile mares by applying gel containing PGE_2 to the surface of oviduct.[12]

Ovariectomy:

Laparoscopic ovariectomy has been done in bovines and is safe and practically feasible in cattle.[25] Although the procedure is time consuming and requires special instrumentation, it is minimally invasive and has a low risk of complications. Further, bilateral ovariectomy can be performed *via* a single flank approach in cattle as both ovaries are situated in close proximity to one another.

Diagnosis of Gross Reproductive Abnormalities:

There have been significant advances in the diagnosis and treatment of reproductive disorders. Diagnostic laparoscopy is currently being utilized on a large scale in humans as well as in animals throughout the world. Laparoscopy has been extensively used for the diagnosis and treatment of various reproductive disorders in human females[39] while in non-human primates; research has also been carried out on the reproductive physiology of the female rhesus macaques throughout the world.[49] The following reproductive anomalies were observed on laparoscopic examination of the genitalia of the female rhesus macaques:[34] ovarian cyst, ectopic pregnancy, ovarian tumor, uterine rupture, uterus unicornis, uterine tumor and uterine edema. Similarly, Sofi[23] evaluated diagnostic potential of transabdominal laparoscopy for evaluation of genitalia with respect to different infertility problems in cattle (Table-1) and proved very helpful and provided confirmation especially to oviduct and adnexal abnormalities.

Table 1. *Reproductive Abnormalities Diagnosed by TAL in Culled Cows*[23]

Genital part	Abnormality/Condition			NO	%age (n=21)
Ovary	True anestrus			2	9.5
	Ovarobursal adhesion	Right	8	13	61.9
		Left	4		
		Both	1		
	Cystic ovaries	Right	1	1	4.8
	Ovarian abscess		2	2	4.8
	Perioophoritis		2	2	4.8
			Total	18	85.7
Oviduct and Adnexa	Hydrosalpinx	Right	2	4	19.0
		Left	2		
	Oviductal adhesion	Right	4	9	42.8
		Left	4		
		Both	1		
	Parovarian cyst	Right	2	3	14.3
		Left	1		
	Tubo-ovarian abscess	Right	1	1	4.8
			Total	17	80.9
Uterus	Uterine adhesion			4	19.0
	Abnormal color with nodules		173.7	4	19.0
	Uterine cyst		179.1	1	4.8
			Total	9	42.8
Total Abnormalities Detected: 44					

Complications:

Complications associated with laparoscopy have been well documented.[22,50-53] Complications may be associated with entry of the abdomen, creation of the pneumoperitoneum, positioning and visualization/manipulation. Placement of ports with the aid of trocars may result in mechanical trauma including injury to major vessels or the gastrointestinal tract, abdominal wall hematoma and perforated bladder. Pneumoperitoneum with CO_2 gas has also been associated with complications such as respiratory acidosis, deep vein thrombosis, subcutaneous emphysema, gas embolism, reduced dynamic lung compliance and increases peak inspiratory and plateau pressures. In humans, shoulder pain due to irritation of the diaphragm or stretching of the phrenic nerve has also been noted following laparoscopic procedures. Short-term complications associated with laparoscopy are generally associated with the surgical incisions; however, post-operative abdominal discomfort or haemorrhage may also occur. However, the best technique to treat complications is to reduce the occurrence of complications.[54]

CONCLUSION

Laparoscopy is currently being utilized on a large scale in humans as well as in animals throughout the world as a latest diagnostic tool. Laparoscopy can be extensively used for the diagnosis and treatment of various reproductive disorders and various aspects of animal reproduction in the future.

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