ANIMAL LAPAROSCOPY

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and David E. Wildt, Ph.D.

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FOREWORD

In recent years the science of laparoscopy has made noticeable strides in advancing our knowledge of physiology and anatomy. Initial advances were made in clinical medicine, particularly with advances in reproductive physiology. In the early 1970s, however, attention turned to research application of the laparoscope. Early studies were descriptive in nature, but soon procedures and techniques were developed which allowed a wide variety of research projects to be performed. Subsequent work allowed reapplication of new research techniques back to clinical practice and veterinary medical use.

Considerable contributions to the field of laparoscopy came from the Endocrine Research Unit of Michigan State University. Beginning in 1969 and continuing to the present, a small group of investigators first developed ancillary research techniques and then applied them to a wide variety of experimental animals ranging from wild to domestic species and including most common laboratory animals. The editors of the present volume were active participating members of that research group.

Dr. R. M. Harrison was instrumental in the application of laparoscopy to the squirrel monkey (*Saimiri sciureus*) and, particularly, the use of this instrument for testing contraceptive effectiveness in this nonhuman primate. Dr. Harrison's subsequent research at the Delta Regional Primate Research Center has further contributed to the knowledge concerning the reproductive physiology in a variety of nonhuman primates.

Dr. D. E. Wildt first developed laparoscopic techniques and procedures for the observation of ovaries in domestic swine. Working with Dr. Harrison, both in Michigan and in Louisiana, he gained experience with the laparoscopy of nonhuman primates and subsequently, at the Institute of Comparative Medicine in Houston, extended his laparoscopic studies to include other domestic animals and many wild species.

Drs. Harrison and Wildt are eminently qualified to edit this book. Their contributions, as individual chapters, are also welcome additions to the libraries of those who use laparoscopy in their research or clinical practice.

W. RICHARD DUKELOW, PH.D.

PREFACE

Laparoscopy (observation through an endoscope inserted into the peritoneal cavity) allows direct viewing of the abdominal and pelvic organs with minor surgical interference and negligible animal trauma. Consequently, for the clinical veterinarian and veterinary or biomedical researcher this procedure has developed into a valuable and positive alternative to laparotomy. The book *Animal Laparoscopy* has been prepared as a guide and source of reference to these professions. The editors' goal has been to provide a definitive text on laparoscopic techniques in animals. To achieve this purpose, information has been presented for the novice or student as well as the experienced laparoscopist. Written and illustrative details have been included to introduce the beginner to various types of laparoscopy equipment and provide step-by-step procedures for performing anesthesia, animal restraint, and various diagnostic and surgical procedures. The experienced laparoscopist will discover that this text provides previously unpublished information, including a detailed explanation on the optical mechanisms of the laparoscope, methods for improving laparoscopic photography, and a description of the most recent laparoscopy equipment suitable for most animal species. Both the beginning and experienced operator should benefit from the discussions for resolving procedural complications and performing the latest clinical and research techniques.

The authors of the various chapters are undoubtedly some of the most experienced in the field and we, the editors, are fortunate to have contributions by some of the pioneers in animal laparoscopy. The experience of the authors varies over a wide range of species, providing the reader with the opportunity to study laparoscopic methods not only in common domestic and laboratory animals but in monkeys, zoo mammals, birds, and reptiles. This information has not been previously available in this detail.

The editors realize that laparoscopy is only one specialized procedure under the general terminology of endoscopy. We have resisted the temptation to dilute the text through descriptive detail of other endoscopic procedures. However, those interested in these other specialized areas of endoscopy (i.e., arthroscopy, cystoscopy, hysteroscopy) will find valuable information in sections on optical principles and instrumentation.

Finally, we acknowledge that, comparatively, animal laparoscopy is a relatively new field, particularly with respect to clinical veterinary medicine. Where applicable, the authors have been encouraged to emphasize their experiences on the use of laparoscopy for performing various clinical procedures, both diagnostic and surgical. In addition, the reader will discover that the authors have discussed the future implications of this technique, often suggesting exciting areas which to date have been essentially untouched. Consequently, it is hoped that this text will not only serve as a valuable teaching and reference source, but also provide impetus for further studies designed to eventually determine the ultimate applicability of laparoscopy in animals.

R. M. H.
D. E. W.

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CHAPTER 1

Historical Development of Laparoscopy in Animals

Richard M. Harrison, Ph.D.

INTRODUCTION

The development of laparoscopic techniques in animals is historically unique. Unlike other biomedical techniques, which were first perfected in animal subjects and later applied to humans, laparoscopy had its origin in human application. Only in the last decade have these techniques been intensively applied to a wide variety of animal species for research and diagnostic evaluations.

EARLY HISTORY

Bozzini's Light Transmitter

The broad field of endoscopy, of which laparoscopy is a specialized component, had its earliest beginnings with the "light transmitter" developed by Philipp Bozzini in 1804 (Rathert *et al.*, 1974). Bozzini's device was a vase shaped, leather covered tin lantern using a wax candle light source (Fig. 1.1). He indicated that it was possible to view into the mouth, nose, ears, vagina, dilated cervix, urethra, female urinary bladder, and rectum with this device. Bozzini claimed that script on a piece of paper, placed in the fundus of a human uterus immediately postpartum, could be seen as clearly using the device inserted through the vagina as if the paper was the same distance from a candle on a table (Bozzini, 1806). In spite of his success, some contemporaries considered his device a mere toy. Bozzini died 5 years later and the ridicule he had received apparently stifled other public reports of such devices for approximately 50 years, although efforts to improve viewing into body cavities continued.

Latter 19th Century

By the mid-1850s, Desormeaux had developed an "endoscope" for examining the urinary bladder (Benedict, 1951). This instrument employed an alcohol lamp flame for light, directing the light by a series of lenses and mirrors to the desired area (Figs. 1.2 and 1.3). In 1868, Kussmaul used a professional sword swallower as a subject to attempt viewing the inside of the stomach through a rigid tube (Balin *et al.*, 1966). Because of the inherent problem of transmitting light down a long viewing tube, this effort was unsuccessful. Bruck, a dentist, used a platinum wire loop, heated by an electrical current

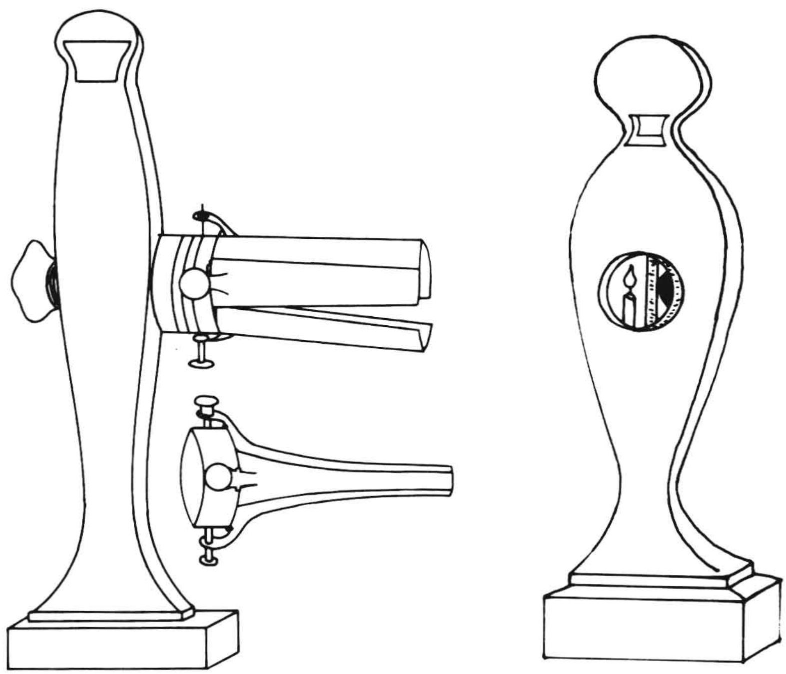

Figure 1.1 Bozzini's light transmitter, circa 1806. **(a)** Device with eyepiece on the left and an expandable cannula attached on the right for viewing cavities such as the vagina or rectum. The cannula in its insertion mode appears below. (Reproduced with permission from *Journal of Medical Primatology* 5:73–81, 1976.) **(b)** Device as viewed from cannula side with cannula removed. Viewing passage is to the right of the central partition, the candle for light is to the left.

to provide greater illumination for inspection of the oral cavity. His "lamp" was the first internal light source (Fig. 1.4) and was later adapted for use in cystoscopy (i.e., examination of the urinary bladder cavity through the uretha). At about this same time, Pantaleoni used a device in women, similar to that developed by Desormeaux, to examine the uterine cavity transcervically (Silander, 1963), a procedure currently termed hysteroscopy.

These early endoscopists encountered two technical problems. First, when viewed through a cylindrical tube without the aid of lenses, the field of vision decreases as the length of the tube increases. This was the circumstance in these early investigations and, consequently, only those structures directly in line of sight could be observed. Second, these attempts were stifled by the lack of an adequate light source. The use of flames was often insufficient and necessitated reflection of the light into the cavity to be examined. Although the incandescent platinum wire loop did provide the additional light required for endoscopy, it had a short life expectancy and was also capable of traumatizing tissue due to heat generation. By the late 1870s, significant technological advancements in instrumentation had partially solved these problems. To broaden the visual field, Nitze, in cooperation with Leiter, incorporated optical lenses into the cystoscope (Fig. 1.5) so that structures outside the direct line of vision could be observed. The incandescent lamp was invented by Edison in 1880, and by 1883, Newman had miniaturized the electric light bulb. Dittel, in 1887, incorporated a small bulb into the distal end of the cystoscope to provide adequate illumination within the bladder cavity

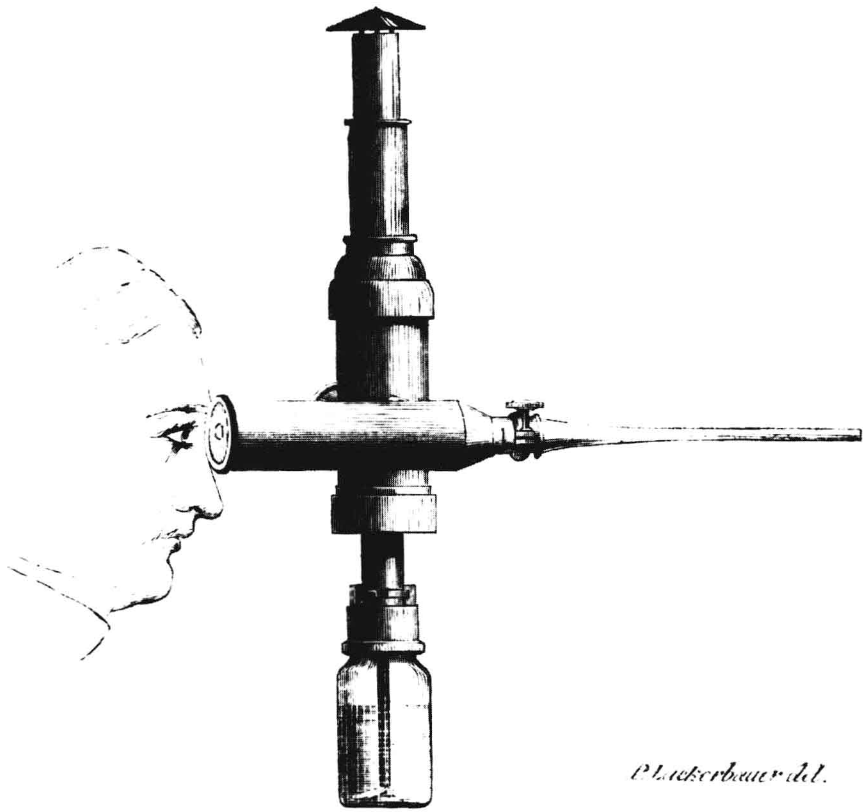

Figure 1.2 Desormeaux's endoscope, circa 1853. Device as it appeared in use. (Reproduced with permission, courtesy of National Library of Medicine, Bethesda, Maryland.)

(Fig. 1.6). Although this did solve the illumination problem, new problems developed, including trauma burn, excessive heat generation, and frequent bulb burn-out requiring the withdrawal of the instrument and bulb replacement.

Early 20th Century

A new approach was described in 1901 by von Ott of Petrograd who placed patients in an extreme Trendelenburg position and then viewed the pelvic organs through an incision in the vaginal cul-de-sac. Illumination was provided by an incandescent lamp reflected by a head mirror through the incision. Although von Ott termed his procedure ventroscopy, it is considered the forerunner of the modern culdoscopy procedure.

The Nitze cystoscope provided the investigator with adequate illumination within a cavity and a wide field of vision. These characteristics allowed for the eventual adaptation of this instrument for viewing into cavities other than the urinary bladder. Kelling (1902) first reported the use of such a device for examining the abdominal organs of a dog and termed the procedure coelioscopy. The technique, as later described by Nadeau and Kampmeier (1925), involved applying a local anesthetic to a small area of the ventral abdominal wall, followed by the intraabdominal insertion of a Fiedler puncture needle. Filtered air was passed through the needle to establish a pneumoperitoneum, and then a trocar-cannula was inserted into the cavity through the anesthetized area and its stylet replaced with the thinnest Nitze cystoscope. Some eight years later Kelling (1910) announced that the procedure had been used on humans. In 1923, he

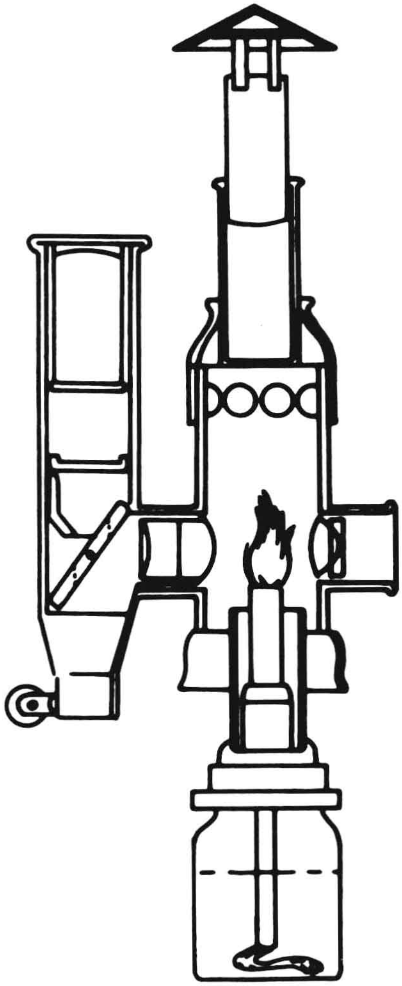

Figure 1.3 Desormeaux's endoscope. Cut-away view with cannula removed and viewing tube rotated 90°. The mirror and lens to the right and left, respectively, of the alcohol lamp flame concentrated light into the viewing tube. The mirror in the viewing tube reflected the light into the desired area and had a hole in the middle to allow viewing. (Reproduced with permission from *Journal of Medical Primatology* 5:73–81, 1976.)

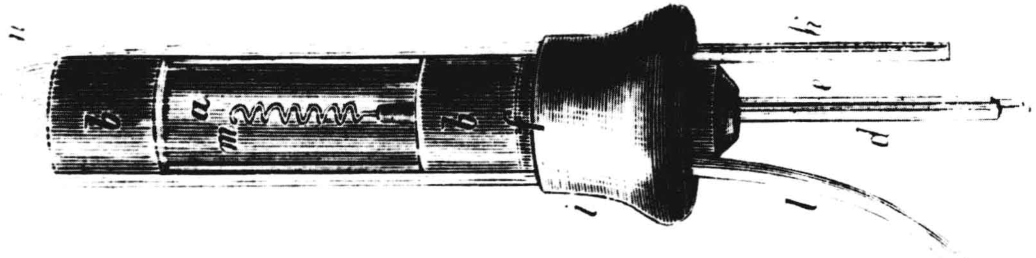

Figure 1.4 Bruck's platinum wire loop, 1868. This electric lamp required circulating water for cooling but provided the first internal light source for endoscopy. (Reproduced with permission, courtesy of National Library of Medicine, Bethesda, Maryland.)

reported that the postwar economic situation in Germany had made it necessary to reduce hospital costs and that he had reduced the number of surgeries by increasing the diagnostic use of his procedure. By this time, Kelling's methodology had been simplified to a single puncture technique with pneumoperitoneum being established after trocar insertion.

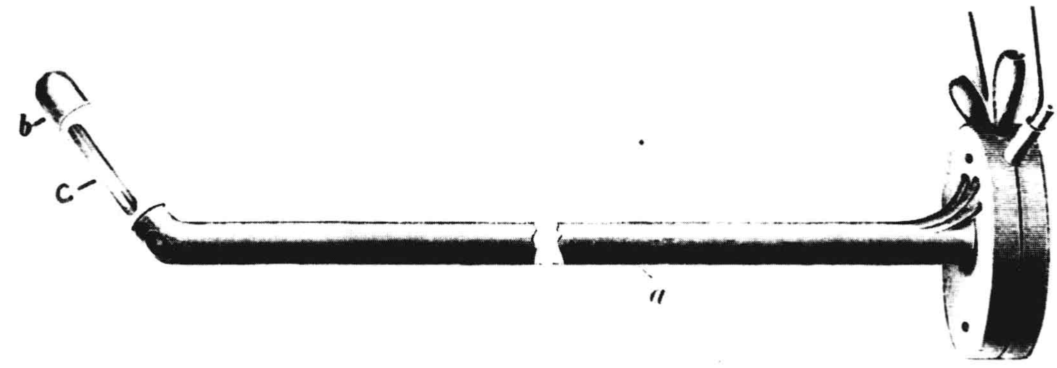

Figure 1.5 Nitze's cystoscope—early model with heated wire light source **(c)**. (Reproduced with permission, courtesy of National Library of Medicine, Bethesda, Maryland.)

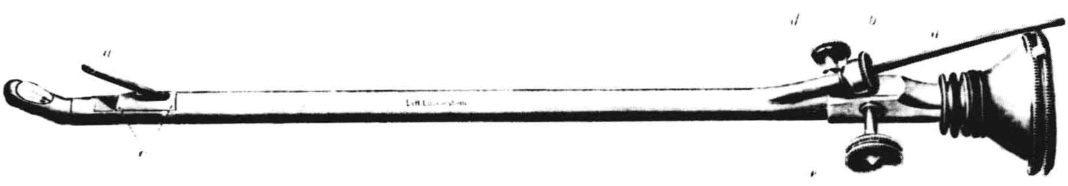

Figure 1.6 Nitze's cystoscope—later model with electric bulb illumination shown with ureteral probe inserted through channel. (Reproduced with permission, courtesy of National Library of Medicine, Bethesda, Maryland.)

Much of the honor Kelling should have received was instead accorded to Jacobaeus who independently developed a technique similar to Kelling's and reported the details eight years later (Jacobaeus, 1910). Jacobaeus published a number of reports on the clinical application of "thoraco-laparoscopy," i.e., endoscopy of the pleural, pericardial, and peritoneal cavities. In this latter procedure, initial insufflation was achieved through separate puncture needles and the trocar-cannula contained a trap valve which prevented air from escaping when the stylet was removed.

Jacobaeus is credited with the first use of the term "laparoscopy" to describe the technique of endoscopy of the peritoneal cavity. Although Kelling did not use the term to refer to his own work, this investigator's earlier use of the techniques in dogs would establish Kelling as the "father of veterinary laparoscopy."

The procedure used by Jacobaeus in humans was reported to be useful for the diagnosis of metastatic nodules of the liver, gastric carcinoma, and general carcinosis of the intestines. Using a modified procedure, he performed thoracoscopy and developed techniques for separating pleural lesions by galvanocautery to gain maximum therapeutic value of artificial pneumothorax in the treatment of pulmonary tuberculosis. After 1913, most of Jacobaeus' efforts continued in thoracoscopy, which he believed to be the procedure of most future value.

At about the same time, but unaware of the works of Kelling and Jacobaeus, Bernheim (1911) described a procedure termed "organoscopy" for visually diagnosing the abdominal state. This investigator used a proctoscope and an electric headlight for illumination. Details of his procedure were not reported, but clear viewing of the ventral surfaces of the liver and stomach and all portions of the gallbladder were claimed. This procedure of examining abdominal organs through a lensless tube appeared to be a retrogressive step to the procedure described by von Ott. However, others have continued to use similar techniques for many years and the modern minilaparotomy procedures may be considered the eventual result of these initial efforts.

During the next 30 years, the technique of abdominal endoscopy or laparoscopy was refined and used for the diagnosis of many abnormal conditions in human patients. Nordentoeft (1912) developed and patented an instrument called a "trocar-endoscope." He claimed the instrument could be used for suprapubic cystoscopy, arthroscopy of the knee, and observations within the body cavities of animals. By placing a female cadaver in a Trendelenburg position, Nordentoeft observed the pelvic organs, and reported a striking view when the abdomen was inflated. His clinical use of the technique was not reported, but his paper was the first to focus on the usefulness of endoscopy to view the pelvic organs in contrast to the upper (cranial) abdominal organs. In the same year, Tedesko reported trials with laparoscopy in patients with ascites before the Society of Internal Medicine and Pediatrics in Vienna. The resulting discussion by participants of this meeting indicated that some of those who had tried the procedure were satisfied and continued to use it, whereas others rejected it as too dangerous. Stolkind (1919), a Russian, restricted the use of laparoscopy to those cases where an exploratory laparotomy was contraindicated, an opinion almost diametrically opposed today. Renon (1913) of France, considered laparoscopy an excellent tool for the diagnosis of certain liver and peritoneal diseases but of little value in the diagnosis of intestinal lesions. Laparoscopy, in concert with X-ray and fluoroscopy, was used by Orndoff (1920) to diagnose tubercular peritonitis, hemoperitoneum, hydroperitoneum, ectopic pregnancy, and abnormalities of the ovaries and oviducts. The use of a pneumoperitoneum to facilitate laparoscopic examinations was well-presented by Orndoff (1920), Alvarez (1921), van Zwaluwenburg and Peterson (1921), and Peterson (1922). In 1921, Case reported four deaths resulting from air embolism following pneumoperitoneum. However, six years later, Sante (1927) reported 1000 cases where pneumoperitoneum was used with no side effects. As a result of these and other studies, some form of pneumoperitoneum continues to be used by all modern laparoscopists.

In Italy, Roccavilla (1914, 1920) modified the Kelling and Jacobaeus method by designing an instrument which used an external light source that was reflected into a trocar tube. An ocular placed above the tube and in direct line of view magnified the internal illuminated field. The trocar tube was designed to accommodate a Nitze cystoscope. In an effort to document laparoscopic observations, Korbsch (1921) of Germany, had watercolor sketches made of the views seen by laparoscopy. In some cases, the laparoscope was in place in the patient's abdominal cavity for three hours with no reported postoperative patient discomfort. Korbsch inflated the abdomen through a puncture needle that was closed at the lower end but had a lateral slit, similar to the Verres needle used today. Zollikofer (1924) of Switzerland reported that laparoscopy was the most practical means for the diagnosis of liver diseases. This investigator's efforts were noteworthy since he was the first to use carbon dioxide for insufflation because of its rapid absorptive characteristics. A nasopharyngoscope was used through the abdominal wall in dogs by Stone (1924). The trocar tube was fitted at its outer end with a rubber gasket to prevent insufflatory air loss. His experiences were limited to experimental work on dogs.

An unusual report by Steiner in 1924 described a technique termed "abdominoscopy," endoscopy of the abdominal cavity. Steiner considered this a "new" means of diagnosing abdominal diseases but described a technique quite similar to those of Kelling, Jacobaeus, Orndoff, and others. Steiner's abdominoscope resembled a cystoscope but with a moveable curved end which was used to move organs and thereby facilitate visualization. Insufflation was performed through a canal in the endoscope. Steiner's report is of value in that it emphasized the importance of patient positioning to examine various organs and described techniques for viewing the gallbladder, stomach, spleen, appendix, and other pelvic organs.

MODERN HISTORY

Developments in Human Laparoscopy

Many endoscopists consider Kalk the father of modern endoscopy because of his prolific publication in the field and his contributions to instrument development. He published more than 20 papers on laparoscopy between 1929 and 1939 which contributed to its widespread promotion. In addition, Kalk introduced the forward oblique 135° viewing system which was responsible for improving the popularity of laparoscopy in Europe (see Chapter 2 for illustrations of various directions of view). In comparison to the direct forward telescope, the forward oblique instrument provided a larger viewing area by rotating it on its long axis without changing the direction of the axis. Kalk's laparoscope with certain modifications is still used today.

Ectopic pregnancy was successfully diagnosed by Hope (1937) using laparoscopic techniques. Ruddock (1937) reviewed 500 laparoscopic cases and found that the technique was 67 to 100% effective for correctly diagnosing diseases of the abdominal organs. He also reported one death due to excessive biopsy hemorrhage, eight punctures of small bowel, colon, or stomach, and three unsuccessful attempts due to extensive adhesions in the abdominal cavity. By 1949, Ruddock had made laparoscopic examinations for diagnostic purposes in over 2500 cases. The patients ranged in age from six months to 85 years and were about equally distributed as to sex. Over 1000 biopsy samples were obtained. Ruddock (1937) noted that by changing the tilt of the table various organs could be viewed, including the liver, gallbladder, lower tip and edge of the spleen, the omentum, occasionally the appendix, greater curvature and anterior surface of the stomach, small intestine, large intestine, urinary bladder, uterus, oviduct, and ovary, all from a single infraumbilical puncture.

Anderson (1937) began to conduct experiments in living dogs using a right angle cystoscope and the flexible cannula and trocar designed by Nadeau and Kampmeier (1925). Anderson had a special gastrodiaphane (small electric light bulb passed through an esophageal tube to the stomach) made for use in humans that allowed for air dilation of the stomach and transillumination of the anterior wall and greater curvature. Similar techniques allowed study by transillumination of the colon and urinary bladder. Anderson reported that laparoscopy could be used to sever abdominal adhesions, incise ovarian cysts, and sterilize women by endothermic coagulation of the oviducts. This was the first reported use of laparoscopic techniques for sterilization.

Distal illumination with the light source as a component of the telescope itself is still employed in some laparoscopes today. However, the development of proximal light projection systems which eliminated the dangers of thermal tissue injury increased the practicality and usefulness of laparoscopy. Initially, quartz rods were used to transmit light from a proximal light source. The endoscope developed by Fourestier utilized this means of proximal light projection. Light from an external projector was reflected by a prism to the end of a clear rod of fused quartz. The quartz rod and the telescope both passed through a common sheath or cannula (Fig. 1.7, Balin *et al.*, 1966). This removed all danger to the patient and provided sufficient light for photographic documentation, but the quartz rods were costly, fragile, and cumbersome. By the early 1950s, Hopkins and Kapany in England, and van Heel in Holland (Kapany, 1958) had begun development of a system for light transmission through flexible fiber optic glass bundles. The use of a "cold" light transmission from an external projector and the return of a clearer, brighter image from the internal structures viewed was possible with the new laparoscopic telescopes containing the Hopkins lens system and fiber light bundles (Fig. 1.8). These refinements allowed the investigators to obtain true color photographs, motion pictures, and television images of the internal organs as seen by laparoscopy.

Palmer (1947) used laparoscopy to investigate causes of infertility. This investigator

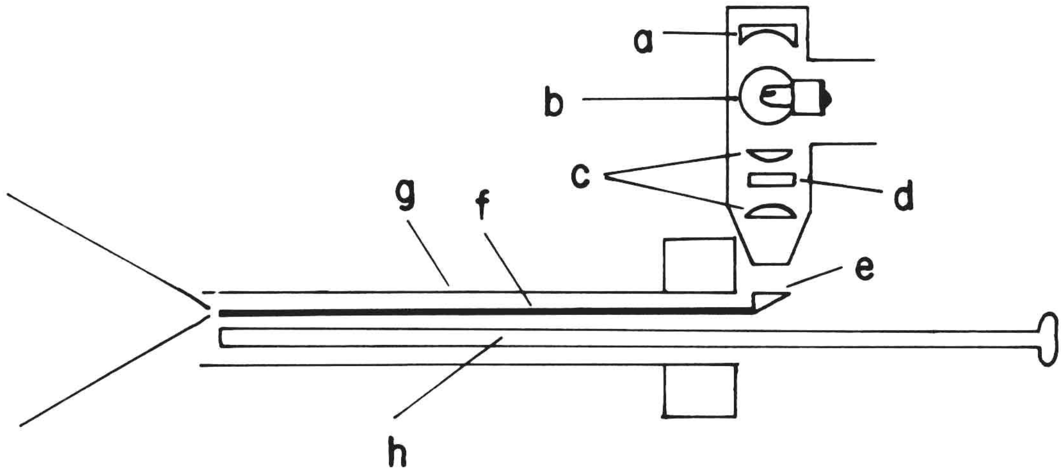

Figure 1.7 Diagram showing early light projection system using a quartz rod as a light guide: **(a)** reflecting mirror; **(b)** incandescent bulb; **(c)** condenser lenses; **(d)** catathermic glass; **(e)** prism; **(f)** quartz rod; **(g)** common sheath; and **(h)** telescope.

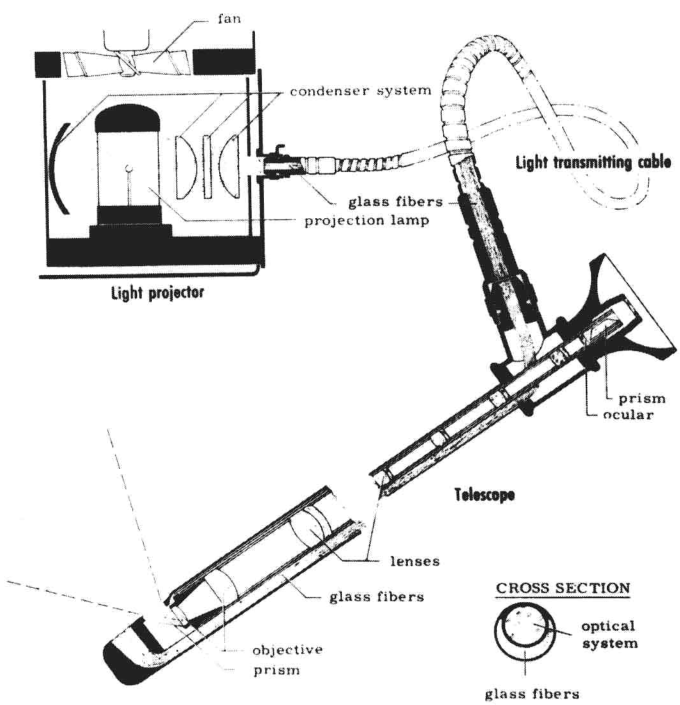

Figure 1.8 Diagram of fiber optic light system in a modern laparoscope. Light from the projector is transmitted via a detachable, flexible light cable to the laparoscope and through the instrument by the glass fiber guides. Heat produced by the lamp is mainly eliminated by filters; the rest is absorbed by the glass fibers so that the light leaving the distal end of the laparoscope is cold light. (Reproduced with permission of M. R. Cohen, *Laparoscopy, Culdoscopy and Gynecography,* W. B. Saunders Co., Philadelphia, 1970.)