SURGICAL APPLICATION OF LASERS

Second Edition

JOHN A. DIXON

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PREFACE TO THE FIRST EDITION

As developments in laser technology have permitted wider and wider application of this method in surgical procedures, those in the field have begun to encounter a great variety of health professionals desiring information. These individuals emerge from areas ranging from general surgery through dermatology. The training status of each varies from full professor or mature practitioner through residents and medical students. Questions are asked such as, "Where can I find basic information on how lasers function? What different types of lasers and wavelengths are there? How do different wavelengths vary in their effect on tissues? What clinical applications of the laser have been made in my field? What is the best type of laser for my purpose? What are the indications, contraindications, and complications of the clinical application of lasers? Could the laser be used for a specific and difficult problem? What safety precautions are essential?" Those seeking knowledge usually leave our office weighed down with hopelessly theoretical physics texts, a stack of poorly reproduced reprints from the current or semicurrent literature, and a scattering of promotional brochures from the various laser manufacturing marketing divisions. Our best wishes go with these inquirers since they typically experience a tedious and frustrating process of extracting the desired and requisite information from these diverse sources.

This text is prepared as a basic reference for these individuals and brings together in one volume information that now must be ferreted out from multiple sources. In the presentation of this material, we have drawn heavily upon our friends throughout the world who have offered great personal insight and information in areas of their recognized expertise and experience. To them I am grateful and express appreciation. The initial chapters provide a brief introduction to the field and an overview of the physical principles of lasers. Subsequent chapters are presented by authors in each of the surgical disciplines and consist of practical discussions of the clinical application in each area with emphasis on surgical indications, contraindications, techniques, and results. Inasmuch as this is an initial publication in a rapidly de-

veloping field, no attempt has been made to include a discussion of all the research in the field or even to cite all clinical applications, which in some instances may be so few as to be almost anecdotal. Ophthalmology is not discussed, owing to the unique and specialized literature in this area.

It is the aim of this book to provide an initial basic background and discussion of the practical clinical surgical applications of lasers in order to provide understanding and to stimulate interest, participation, and further investigation in this fascinating and rapidly evolving field.

JOHN A. DIXON, M.D.

PREFACE TO THE SECOND EDITION

Since the preceding preface was written 5 years ago, tremendous changes have occurred in the field of laser surgery. Dramatic advances have occurred in earlier laser specialties involving otorhinolaryngology, dermatology/plastic surgery, gastroenterology, and urology. In addition, new fields that were only mentioned in the first edition have merited separate chapters, such as selectivity of light/tissue interaction, laser instrumentation and safety, cardiovascular applications, orthopedic surgery, pulmonary and photodynamic therapy, and photobiology.

Many excellent texts have been published recently describing in-depth developments in a number of specialty fields. These will be referenced in appropriate chapters.

The initial intent for the second edition was to again provide an introduction with basic physics and safety presentations but to include in the clinical section only "orphan" specialty areas that have not merited recent full text treatment. However, conversations with clinicians, academicians, and trainees indicate a continuing need for a broad introductory multispecialty volume for those beginning their endeavors in laser surgery. The aim of this edition remains as defined in the last paragraph of the preface to the first edition.

The book begins with basic science chapters helpful in understanding and applying clinical techniques. This is then followed by "highlight" presentations in each specialty. Rather than the usual anatomical association of topics, the specialty chapters appear in order of "maturity" as measured by numbers of patients and amount of applications and experience with indications and contraindications. Utilizing this index, the common and extensive otolaryngological applications appear first and the new photodynamic techniques last.

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CONTENTS

1 Introduction: Implementing a New Technology

John A. Dixon, M.D.

Why use a laser for a surgical procedure? For centuries surgeons have been able to accomplish their tasks without the help of this new and relatively untested device. The answers to this fundamental question can be provided by analytic surgeons and their patients. From the surgeon's standpoint, gaining access to some areas of the body is an awkward and tedious procedure. Control of bleeding is made difficult by coagulopathies, friable tissue, highly vascular solid organs, and angiomatous lesions. Some surgical lesions (e.g., those involving the vocal cords, trachea, and bronchi) are inaccessible to standard cut, tie, or ligature techniques. Others, such as pelvic endometriosis or colonic polyposis, involve multiple nodules or tumors attached or adjacent to other viscera, which makes removal difficult or impossible. The potential advantages provided by the laser to the surgeon are as follows:

1. Multiple wavelengths with selective absorption by various tissues.
2. Selective tissue ablation by modification of pulse characteristics and photosensitizers.
3. Transmission through flexible wave guides that can be passed through standard endoscopes (with the exception of CO_2 lasers).
4. Ability to coagulate, vaporize, or cut by varying the power and time of application.

At the present state of the art, there are also disadvantages in application of the laser as a surgical tool. These are:

1. Special training of surgeons in use of endoscopes and lasers.
2. High cost of equipment.

3. Lack of portability of instruments.
4. Requirements for special wiring and plumbing for water cooling.
5. Hazards to patient and personnel from inadvertent laser exposure, electrical injury, or fires.
6. Complex maintenance of an evolving technology.

From the patient's standpoint, current surgical procedures might be criticized as associated with painful incisions, necessity for prolonged hospitalization with attendant costs, potential for infection in incisional or operative sites, or the requirement for multiple operative procedures. The potential advantages of laser surgery to the patient are:

1. Avoidance of hospitalization.
2. Substitution of endoscopic access for incisional access in surgical procedures with reduction in pain and infectious complications.
3. Reduction in period of convalescence.
4. Availability for treatment of previously inoperable lesions.

As with most drugs, procedures, and instruments, the laser has gone through a phase of rather unrestrained initial enthusiasm, followed by pessimism induced by the inevitable appearance of complications, restrictions, limitations, and inadequacies. Again, as with all previous innovative techniques, the surgical application of lasers is now beginning to find its more permanent niche in surgical practice. The laser should not be used when simpler techniques can accomplish the same result. Application should be considered when standard surgical techniques are not available or suboptimal. As careful experimental and clinical research using lasers is carried out in those areas of conventional surgical deficiency, indications and contraindications in surgical practice will be more clearly defined.

It is suggested that readers of this book carefully review Chapter 2 covering physical principles of lasers. In this age of specialization, the reader might then wish to review the clinical chapter that relates to his or her specialty, followed by a review of Chapter 17 on possible future applications of the laser. As laser use overlaps considerably in the various specialty fields, it is suggested that perusal of the other chapters will be useful to provide a perspective of laser applications and capabilities.

Since the history of lasers in surgery is covered in Chapter 2, the remainder of this chapter is devoted to issues relating to the introduction of a new surgical instrument and technology. The detailed orga-

nizational outline is presented in response to requests from colleagues interested in establishing a laser surgical program.

In nearly every clinical chapter, there is some mention of the necessity for eye protection and safety precautions, some of which may seem repetitive. Since these are such important points, and because some readers might review only that clinical chapter related to their particular specialty, the reiteration is deliberate. A list of common laser terms appears at the beginning of Chapter 2.

INTRODUCING A NEW SURGICAL TECHNOLOGY

The endoscopist or surgeon usually becomes aware of the possible application of the laser to his or her field by reading a paper, hearing a presentation, or seeing a tape or movie depicting a unique or specialized application of the laser. The initial contact may be reinforced by a visit from the friendly neighborhood laser vendor who acquaints the potential laser surgeon with the availability and advantages of a particular laser device. The endoscopist-surgeon then believes that if patients are available and a laser can be purchased, a clinical program can get underway "tomorrow." Unfortunately, as with all new procedures or techniques, the situation is much more complex.

A long list of perplexing questions and problems soon arises. What space will be required to house the program? How is the surgeon or endoscopist to acquire training in laser/tissue interactions and applications? How are laser privileges to be determined? How is the laser to be financed, depreciated, and replaced when obsolete? Is there special power and water in the operating room or endoscopy suite as required by the laser? Who will be responsible for laser safety, use of protective devices, and checking out laser operating rooms for hazards? Who will take charge of the maintenance and setting up of equipment? What special approvals are required from institutional review boards, hospital boards, and departmental committees? What specially trained supporting personnel will be required?

These questions are posed to provide direction, not discouragement. The answers are not the same for the surgeon in solo practice as for a large clinic or community hospital or health science center. What must really be undertaken is a process of immediate and long-range planning for introduction of the laser into the surgical environment. This is a somewhat taxing exercise, but will be much less so if a number of factors are considered simultaneously rather than a succession of crisis-oriented events or discoveries.

ASSUMPTIONS AS BASIS FOR PLANNING

It is necessary to make assumptions as a basis for all types of planning. These assumptions may later prove to be incorrect, but they at least provide a beginning point for analysis. Assumptions for laser use that may be relevant for many circumstances but that should be modified to suit each individual situation are as follows:

1. That the use of lasers for surgical and endoscopic purposes will increase.
2. That small, modular, less expensive units will gradually replace large immobile or central units. (The possibility of large central power units supplying multiple areas by new communications fibers should be watched carefully as a possible emerging alternative.)
3. That lasers will remain relatively expensive for at least the next five years.
4. That in most settings, the use of the same laser by many individuals and specialties will be necessary to provide acceptable laser instrument costs per procedure.
5. That the development of new laser procedures will increase the number of patients that can be included for cost per treatment purposes.
6. That the number of patients treated will decrease as other surgeons or hospitals in a service area begin to use lasers, depleting the "pool" of laser patients.
7. That as with all new technologies, considerable maintenance of equipment will be required and down time anticipated.
8. That space for housing the laser activity will be difficult to obtain.
9. That a laser safety officer will be required.
10. That coordination of research will be essential to provide for sharing of expertise, ideas, and equipment.
11. That it will be necessary to negotiate new procedure codes and a variety of payment schedules with third party payors and governmental entities.
12. That in larger institutions, an organization will be necessary to constantly review the above assumptions and to make appropriate modifications regarding acquisition and scheduling of equipment, accreditation of individuals for laser use, and training of laser endoscopists and surgeons.
13. That there will be three organizational phases in laser organizational development (Table 1–1), the final phase characterized by the

TABLE 1–1.
Laser Surgery Organizational Phases

Initial	Individual isolated surgeons, one wavelength laser, research-clinical applications (individual control)
Transition	Multiple surgeons, multiple disciplines, several wavelength lasers; clinical but extensive training and new instrumentation (task force control)
Final	Multiple surgeons, multiple disciplines, multiple wavelength lasers; high-volume, well-established clinical applications by trained individuals (decentralized departmental or OR control)

assumption of laser management by established operating room and departmental structures.

In larger institutions, the organizational form required to operate the laser program presents unique challenges. Multiple surgeons, specialties, and disciplines are involved. The activity of persons in the laser unit frequently represents only a small portion of their total practice or research. Individuals may move in and out of laser activity as their interests or results become evident. All of these factors make it difficult to apply the typical departmental or divisional organizational structure, with line authority and responsibility covering all persons involved.

These requirements have been most effectively met in industry by a "task force" format, as described by Lawrence and Lorsch.[1] In this organizational form, a task force leader and staff are responsible for the overall management of the program. Individuals from other departments are then "lent" to the task force or participate in it while maintaining their basic responsibility in their home department or division. This results in an organizational chart (Fig 1–1) with (1) *solid lines* connecting those persons with direct line responsibility and (2) *dashed lines* for those who participate in the task force but maintain primary affiliation elsewhere. Using such a clinical organizational format, 815 laser procedures were carried out at the University of Utah unit in 1981, with minimal trauma, morbidity, and mortality in surgeon-participants. (The same factors in patients so treated are discussed in other chapters in this book.)

In an academic environment, great pressures soon appear, necessitating basic and applied research to understand and facilitate advances in the field. This necessitated the formation of a Laser Institute

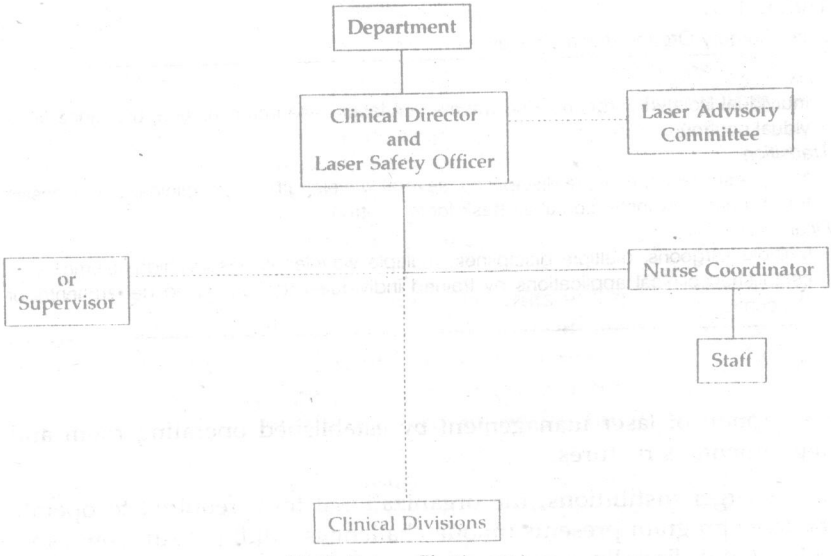

FIG 1–1.
Clinical organizational chart. (See text for explanation.)

at the University of Utah to coordinate and integrate the efforts of a diverse group of surgeons, physicists, chemists, photobiologists, and others. The current organization appears in Figure 1–2 with the clinical division on the right.

Participation is still voluntary with no promotion, retention, or tenure being given by the institute; 1,258 patients were treated in the clinical division in 1986. Numerous grants and sources of support were obtained and managed through the institute, maximizing joint use of funds, space, and equipment.

TASK FORCE FACTORS

The transitional organization format has the advantage of central coordination of the laser program but still provides for individual specialty growth and diversification. Because most institutions anticipate becoming involved at this level, elements will be discussed in considerable detail.

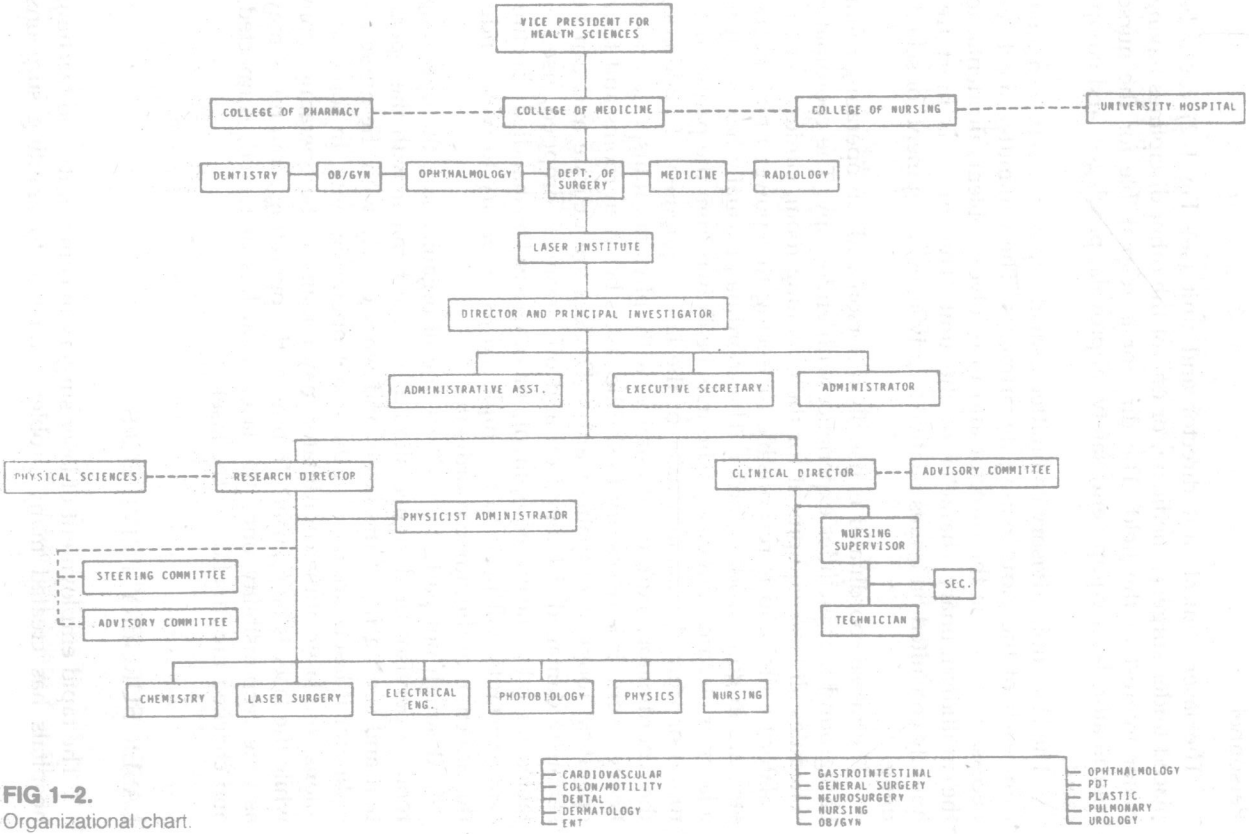

FIG 1–2.
Organizational chart.