International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

# Comparing Minimally Invasive Techniques to Traditional Surgery for Specific Tumor or Cancer Types: A Comprehensive Review

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**Abstract**

Surgical oncology encompasses the use of surgical interventions in the treatment of cancer. Its primary objective is the identification and removal of malignant tumors within the body. Surgeons specializing in this field are tasked with various responsibilities, including preventive measures, early detection of cancerous or pre-cancerous conditions, diagnosis, pre-operative preparation, tumor removal, staging of the disease, post-operative care, rehabilitation, surveillance, emergency interventions, and palliative treatments. The treatment of tumors often involves a combination of surgical procedures, chemotherapy, radiotherapy, and other supplementary therapies. Advancements in medical technology have led to less invasive surgical techniques, particularly in treating benign conditions, resulting in smaller incisions and reduced risks of complications compared to traditional open surgeries. Minimally invasive surgery (MIS) refers to procedures that minimize the size of surgical incisions, leading to decreased blood loss, faster wound healing, reduced pain and scarring, shorter hospital stays, lower infection risks, and fewer post-surgical complications. Consequently, many conditions that previously necessitated open surgery can now be managed through minimally invasive techniques. In contrast, traditional surgery has historically been the standard approach for cancer treatment, involving incisions to directly access and address the affected area. Skilled surgeons utilize their expertise and specialized tools to excise tumors, repair tissues, and conduct necessary procedures.The aim of this project is to evaluate and compare the efficacy of these surgical approaches in the treatment of specific types of tumors or cancers.

## LITERATURE REVIEW

In a Relevant Study regarding the role of minimally invasive techniques in gastrointestinal surgery, The prevalence of gastrointestinal cancer has remained significant in recent years. Surgical resection remains the cornerstone of treatment for gastrointestinal cancer, with traditional open surgery being the longstanding approach. However, conventional open surgery is associated with substantial trauma and prolonged recovery times. Over the past two decades, minimally invasive surgery has emerged as a promising alternative, aiming to mitigate postoperative complications and expedite recovery. Its utilization in gastrointestinal surgery, particularly for early-stage cancer, has surged. Nonetheless, despite its potential benefits, open surgery still predominates in many gastrointestinal cancer procedures. This preference may stem from the challenges posed by minimally invasive techniques, particularly in confined

anatomical spaces like the pelvis or near the upper pancreas. Additionally, some literature raises concerns regarding oncologic outcomes following minimally invasive gastrointestinal surgery. While existing evidence suggests the safety and feasibility of minimally invasive approaches, much of the literature consists of retrospective or case-matched studies. Larger-scale randomized prospective studies are warranted to further validate the efficacy of minimally invasive surgery in gastrointestinal cancer treatment. The high incidence of gastrointestinal tumors has prompted a paradigm shift in their treatment with the advent of minimally invasive surgery. This innovative approach holds promise in reducing surgical complications and expediting postoperative recovery for patients with gastrointestinal tumors.

**Introduction to Minimally Invasive Surgery**

Minimally invasive surgery (MIS) represents a revolutionary approach to surgical interventions, characterized by its ability to accomplish complex procedures with minimal disruption to the patient's body. Unlike traditional open surgery, which involves large incisions, MIS utilizes specialized techniques and instruments to perform surgeries through small incisions. These smaller incisions serve as entry points for tiny surgical instruments and a camera, allowing surgeons to visualize the surgical site with precision on a monitor.

The core principle of MIS is to minimize trauma to surrounding tissues, leading to several significant benefits for patients. These benefits include reduced blood loss, decreased postoperative pain, shorter hospital stays, quicker recovery times, and improved cosmetic outcomes due to smaller scars. Additionally, MIS often results in fewer complications, such as infections and hernias, compared to traditional open surgery.

The adoption of MIS has transformed various surgical specialties, including general surgery, gynecology, urology, and orthopedics. Common procedures performed using minimally invasive techniques include laparoscopic surgeries, endoscopic procedures, robotic-assisted surgeries, and interventions utilizing advanced imaging technologies.

Despite its numerous advantages, MIS requires specialized training and expertise for surgeons to master the intricate techniques and technologies involved. Additionally, access to advanced equipment and resources may pose challenges in certain healthcare settings. However, ongoing advancements in medical technology and increased training opportunities continue to expand the accessibility and applicability of minimally invasive approaches.

In this era of patient-centered healthcare, minimally invasive surgery stands as a testament to innovation and progress, offering patients safer, more efficient, and less invasive treatment options across a wide range of medical conditions. As research and development in this field continue to evolve, the future holds promise for further enhancements in surgical outcomes and patient care through minimally invasive approaches.

**Advantages and Drawbacks of Minimally Invasive Surgery**

**Possible benefits include:**

- Minimized trauma to tissues.
- Reduced blood loss during surgery.
- Lowered likelihood of surgical complications.
- Decreased risk of postoperative infections.

- Diminished scarring.
- Shortened hospitalization duration.
- Quicker recovery period.
- Decreased pain levels and reduced need for pain medication.
- Potential avoidance of general anesthesia.
- Expanded accessibility to surgery for individuals previously deemed ineligible.

**Potential disadvantages encompass:**

- Requirement for specialized training and equipment.
- Limited availability in certain locations.
- Potential for higher costs.
- Prolonged duration of operations.
- Limited applicability in emergency scenarios.
- Risk of cardiopulmonary complications associated with gas insufflation for some patients.

**Introduction to Traditional Surgery**

Traditional surgery, also known as open surgery, has been a cornerstone of medical practice for centuries, serving as a primary method for treating various medical conditions. In traditional surgery, surgeons make large incisions to directly access and visualize the surgical site, enabling them to perform necessary procedures using handheld surgical instruments.

The foundation of traditional surgery lies in the skilled hands of surgeons, who employ their expertise and precision to navigate through tissues, manipulate organs, and address pathological conditions. This hands-on approach allows for real-time assessment and manipulation of tissues, providing surgeons with direct tactile feedback during the procedure.

Throughout history, traditional surgery has played a vital role in treating a wide array of medical conditions, ranging from trauma and injury repair to complex organ transplantation. Surgeons rely on traditional surgical techniques for their versatility, allowing them to perform a diverse range of procedures across various medical specialties.

Despite the advent of minimally invasive techniques, traditional surgery continues to be widely utilized, particularly in cases where the complexity of the procedure or the anatomy of the patient necessitates open access. Additionally, traditional surgery remains indispensable in emergency situations, where immediate intervention is crucial to saving lives.

While traditional surgery offers several advantages, including direct visualization and tactile feedback, it also poses certain challenges and limitations. Large incisions may result in significant trauma to tissues, leading to prolonged recovery times and increased risk of complications such as infection and scarring. Additionally, traditional surgery often requires longer hospital stays compared to minimally invasive procedures, further impacting patient outcomes and healthcare resources.

In conclusion, traditional surgery represents a fundamental aspect of modern medicine, providing surgeons with a time-tested approach to addressing a wide range of medical conditions. While advancements in minimally invasive techniques continue to reshape surgical practice, traditional surgery remains an

essential tool in the surgeon's arsenal, ensuring optimal patient care and outcomes in diverse clinical scenarios.

**Pros and Cons of Traditional Surgery**

Traditional surgery remains a common method for treating various conditions, involving large incisions to access and treat the targeted area. Despite the increasing popularity of minimally invasive surgery, traditional surgery still offers several advantages over robotic systems. Here are the benefits and drawbacks of traditional surgery.

**Advantages of Traditional Surgery:**

- **Enhanced Visibility and Precision:** Traditional surgery provides surgeons with a clear and unobstructed view of the surgical area, allowing for precise procedures, particularly important for delicate and intricate surgeries.
- **Tactile Feedback:** Surgeons can feel structures and tissues more easily, aiding in evaluating tissue texture, temperature, and consistency, providing valuable feedback during the procedure.
- **Versatility:** Traditional surgery can be utilized for a wide range of surgical procedures, from simple to complex, offering flexibility in treating various conditions.
- **Speed:** In certain cases, traditional surgery may be faster than robotic surgeries, beneficial in emergency situations or when time is of the essence.
- **Accessibility:** Traditional surgery is effective for treating tumors or lesions that are difficult to address with minimally invasive techniques, offering broader accessibility compared to minimally invasive approaches.
- **Restorative Procedures:** For reconstructive, repair, or organ transplantation surgeries, traditional surgery allows immediate access and comprehensive efficiency.
- **Training and Experience:** Many surgeons possess extensive experience in traditional surgery, which has been the standard practice for decades, contributing to improved outcomes for certain procedures.
- **Affordability:** Traditional surgery is often more accessible and cost-effective compared to minimally invasive procedures, depending on the specific type of surgery.

**Disadvantages of Traditional Surgery:**

- **Large Incisions:** Traditional surgery involves large incisions, leading to scarring and an increased risk of infection.
- **Prolonged Recovery Time:** Patients undergoing traditional surgery typically experience longer recovery times compared to minimally invasive procedures, resulting in extended hospital stays and delayed return to normal activities.
- **Pain and Discomfort:** The disruption of tissues and large incisions in traditional surgery can cause significant pain and discomfort, often requiring medication for pain management.
- **Blood Loss:** Traditional surgery may result in substantial blood loss compared to robotic surgery, potentially necessitating blood transfusions and increasing the risk of complications associated with excessive bleeding.
- **Scarring:** Visible and prominent scars may develop due to the large incisions in traditional surgery, raising cosmetic concerns for some patients.

- **Extended Hospital Stays:** Traditional surgery may require prolonged hospitalisation for patient monitoring and recovery.
- **Complication Risks:** There is a higher risk of complications such as hernias, wound infections, and abnormal tissue connections associated with traditional surgery.
- **Longer Anesthesia Exposure:** Patients undergoing traditional surgery are exposed to longer periods of anesthesia due to extended surgical times, increasing the risk of anesthesia-related complications.

**What is a tumor?**

A tumor arises when cells undergo rapid reproduction. Defined by the National Cancer Institute, a tumor is "an abnormal mass of tissue resulting from cells dividing excessively or failing to undergo programmed cell death." Tumors vary in size, ranging from minuscule nodules to sizable masses, contingent upon their type, and can manifest in virtually any part of the body.

**Types of Tumors:**

Tumors can be categorized into three primary types: benign, premalignant, and malignant. Malignant tumors are cancerous, while other types are noncancerous.

***Benign:*** These tumors lack cancerous properties and do not infiltrate neighboring tissue or metastasize to distant sites. Typically, they do not recur after surgical removal.

***Premalignant:*** Cells within these tumors are not yet cancerous but possess the potential for malignant transformation.

***Malignant:*** Malignant tumors exhibit cancerous characteristics, with cells capable of proliferating and disseminating to other anatomical locations.

The behavior of a tumor in the future is not always predictable. Certain benign tumors may progress to premalignant stages and subsequently become malignant. Consequently, regular monitoring of tumor growth is advisable.

**Tumor vs. cyst**

Tumors and cysts share similarities in appearance and can develop on various body parts. However, tumors consist of solid tissue masses, while cysts are sacs containing fluid or air. Due to their composition, cysts may feel softer upon palpation compared to tumors, which typically exhibit firmness. Nonetheless, some benign tumors may also exhibit a softer texture.

**Benign Tumors and Their Characteristics**

Benign tumors are typically non-threatening and tend not to metastasise to other body parts. However, they can cause discomfort or complications if they exert pressure on nerves or blood vessels or stimulate excessive hormone production, particularly within the endocrine system. Examples of benign tumors include:

**Adenomas:**

Adenomas originate in glandular epithelial tissue, which forms the protective membrane covering glands, organs, and other structures in the body. Examples include colon polyps, fibroadenomas (common benign

breast tumors), and hepatic adenomas found in the liver. While adenomas do not initially exhibit cancerous characteristics, some may undergo changes and transform into adenocarcinomas, which are malignant.

**Fibroids:**
Fibroids, also known as fibromas, are benign tumors that develop on fibrous or connective tissue within any organ. Uterine fibroids are prevalent and can lead to symptoms such as vaginal bleeding, pelvic discomfort, or urinary incontinence. Fibroids may vary in texture, categorized as "soft" or "hard," depending on the ratio of fibers to cells. Various types of fibromas exist, including angiofibromas and dermatofibromas. Although most fibroids are benign and do not require treatment, some may necessitate surgical intervention. In rare instances, fibroids may undergo malignant transformation into fibrosarcomas.

**Hemangiomas:**
Hemangiomas are benign tumors arising from excessive growth of blood vessels, often appearing as discoloured skin marks or developing internally. Frequently present from birth, hemangiomas typically resolve on their own during childhood and rarely require treatment. However, if intervention is necessary, options such as laser surgery are available.

**Lipomas:**
Lipomas are soft tissue tumors comprised of fat cells, commonly affecting individuals aged 40 to 60 years. Generally non-cancerous, lipomas manifest as small, painless, movable, and rubbery growths, often found on the back, shoulders, arms, buttocks, or tops of the legs. Variants of lipomas include fibrolipomas, containing fat cells and fibrous connective tissue, and angiolipomas, which emerge beneath the skin.

**Premalignant Conditions and Their Characteristics**
This category of tumors is not cancerous, yet necessitates close monitoring by medical professionals for potential changes. Examples include:

**Actinic keratosis**
Actinic keratosis, also known as solar keratosis, manifests as crusty, scaly skin patches that are thicker than usual. It is more prevalent in fair-skinned individuals, with increased sun exposure elevating the risk. Actinic keratosis can occasionally progress into squamous cell carcinoma.

**Cervical dysplasia**
Cervical dysplasia involves alterations in the cells lining the cervix, often detected through a Pap smear. Linked to the human papillomavirus (HPV), particularly common in young individuals, cervical dysplasia is not initially cancerous. However, it may transform into malignancy 10–30 years later, potentially leading to cervical cancer. Surgical interventions, such as freezing techniques or the removal of a tissue cone from the cervix, may be employed to address these abnormal cells.

**Metaplasia of the lung**
Metaplasia of the lung occurs in the bronchi, the air-carrying tubes leading into the lungs. Glandular cells

lining the bronchi can transform into squamous cells or cancer, particularly in individuals with a history of smoking.

**Leukoplakia**

Leukoplakia causes the formation of thick white patches in the mouth, characterized by their painless nature, irregular shape, raised edges, and inability to be scraped off. Individuals with such patches should consult a doctor if they persist over time. Monitoring for changes and ceasing smoking or tobacco use is advised. If there is a concern about potential cancerous development, a doctor may opt for removal using a laser or surgical scalpel.

**Understanding Malignant Tumors**

Malignant tumors signify cancerous growths resulting from uncontrolled cell proliferation. If left unchecked, these cells can pose life-threatening consequences. Malignant tumors exhibit rapid growth and have the propensity to metastasise, spreading to distant parts of the body. However, not all malignant tumors proliferate swiftly; some may progress slowly over time. The cancerous cells that disseminate to other organs maintain their original characteristics, yet they can infiltrate and affect different tissues. For instance, if lung cancer metastasizes to the liver, the cancerous cells in the liver retain their lung cancer identity. Various types of malignant tumors arise from distinct cell types:

**Carcinoma:** These tumors originate from epithelial cells, which line the body's organs and tissues, including the skin. Carcinomas can manifest in organs such as the stomach, prostate, pancreas, lung, liver, colon, or breast, representing a prevalent form of malignancy.

**Sarcoma:** Sarcomas develop in connective tissue, encompassing cartilage, bones, fat, and nerves. These tumors originate outside the bone marrow and predominantly exhibit malignant behavior.

**Germ cell tumor:** Originating from cells responsible for sperm and egg production, germ cell tumors typically arise in the ovaries or testicles but may occur in other regions such as the brain, abdomen, or chest.

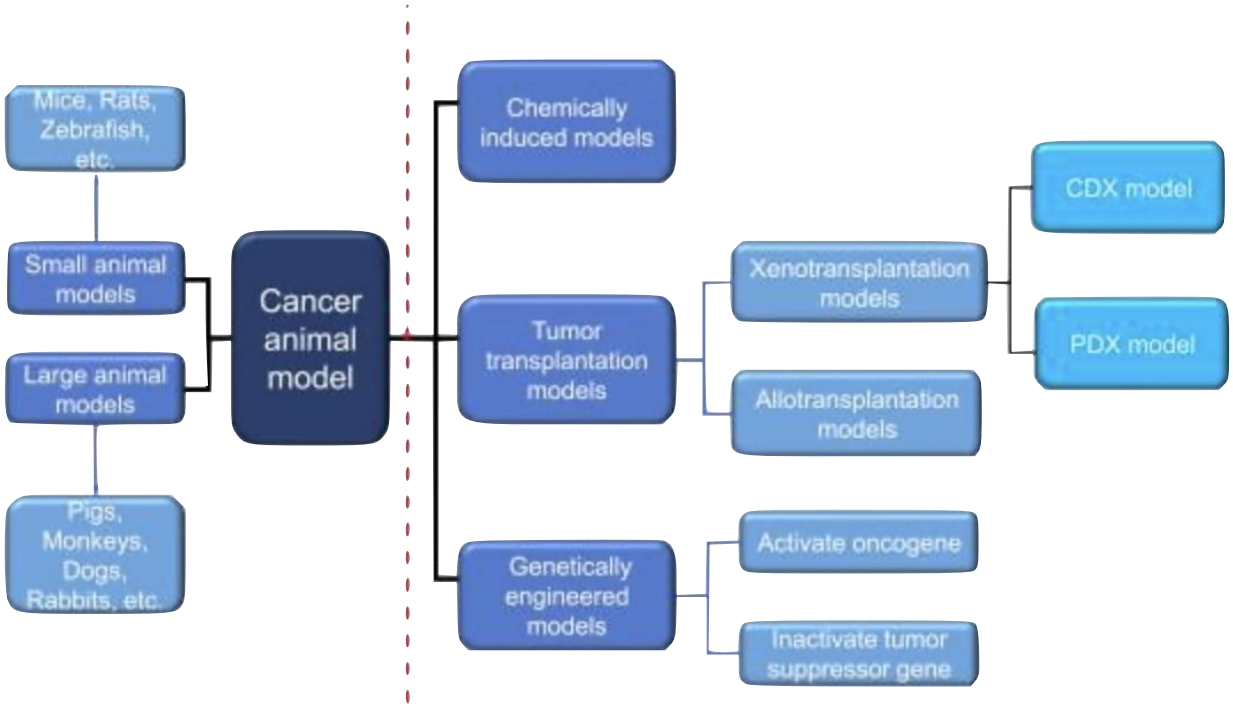
**Blastoma:** These tumors derive from embryonic or developing cells and are more frequently observed in children than adults. Blastomas can lead to tumor formation in the brain, eye, or nervous system.

**Meningiomas:** Among the most prevalent types of brain tumors, meningiomas may necessitate surgical excision or treatment if symptomatic.

**Criteria for Patient or Animal Model Selection**

Animal models are experimental systems and materials used to mimic the human body in medical research. Cancer, as the second-leading cause of morbidity and mortality globally after cardiovascular disease, remains a focal point in medical research. Consequently, various animal models have been developed and employed in cancer research, reflecting the growing diversity in construction methods such as chemical induction, xenotransplantation, and gene programming. In recent years, patient-derived xenotransplantation (PDX) models have garnered significant attention due to their ability to preserve the microenvironment and fundamental characteristics of primary tumors. These animal models serve not only to investigate the biochemical and physiological processes underlying cancer development but also to facilitate drug screening and gene therapy exploration.

Numerous animal species and construction techniques are utilized in the creation of cancer models, each offering distinct advantages and contributions to tumor research.




**Mouse Model**

The mouse genome shares significant homology with the human genome, allowing it to mimic various biological characteristics including the onset, progression, and metastasis of human cancer cells in vivo. This model offers advantages such as ease of maintenance, affordability, and straightforward genetic modification, making it an invaluable tool in cancer research and drug development. Currently, there are four primary methods for generating mouse cancer models: chemically induced models, cell line-derived xenograft (CDX) models, patient-derived xenograft (PDX) models, and genetically engineered mouse models (GEMMs).

Chemical induction involves the initiation of experimental tumors using chemical carcinogens, offering a representation of the early stages of human cancer development. However, this method requires a significant timeframe of 30-50 weeks for tumor formation post-carcinogen exposure. CDX models, created through subcutaneous injection of cancer cell lines into immunodeficient mice, offer a simpler and quicker tumor formation process. Nonetheless, long-term in vitro culture may lead to biological differences and tumor heterogeneity compared to the original tissue. PDX models involve directly implanting tumor tissue samples from patients into mice, preserving key histopathological and genetic characteristics of tumors. GEMMs induce tumorigenesis through genetic engineering, such as overexpression of oncogenes or deletion of tumor suppressor genes, producing tumors within an immune-proficient microenvironment. However, due to species-specific differences in the immune system among mammals, existing models may not accurately predict interactions between the human immune system and tumors. Consequently, there is a need for animal models that replicate the tumor microenvironment while possessing a humanized immune system.

Humanized mouse models of the immune system reconstruct the human immune system by implanting human hematopoietic cells, lymphocytes, or tissues into immunodeficient mice. These models allow for the study of tumor growth within a human immune system environment, particularly in evaluating immunotherapy effects and mechanisms. Various human tumor cell lines have been successfully established in humanized mice, covering a range of cancers including lymphoma, glioma, breast cancer,

colorectal cancer, kidney cancer, and prostate cancer. Humanized mouse models of the immune system are categorized into three types based on the method of human immune system reconstruction: Hu-BLT (human bone marrow, liver, and thymus) model, Hu-HSCs (human hematopoietic stem cell) model, and Hu-PBL (human peripheral blood lymphocyte) model.

**Hu-HSC Model**

Creating this model involves ablating bone marrow hematopoiesis in immunodeficient mice, either as newborns or adults, followed by the infusion of human hematopoietic stem cells (HSCs). These HSCs differentiate into various immune cells, including B cells, T cells, NK cells, and myeloid cells. These immune cells interact with the implanted tumor cells, simulating the tumor microenvironment. Meraz et al. established a Hu-HSC model using fresh umbilical cord blood CD34+ HSCs to study the immune response in lung cancer. While the Hu-HSC model can replicate aspects of the human innate immune system and lymphocytes, it does have limitations. For instance, detection of low-activity human T cells in peripheral blood may take up to 12 weeks after HSC implantation into mice.

**Hu-PBL Model**

The Hu-PBL model is established by introducing human peripheral blood lymphocytes into immunodeficient mice. It currently stands as the simplest and most cost-effective humanized mouse model available. This model has been extensively utilized in various cancer research fields, including lung cancer, thyroid cancer, cervical cancer, breast cancer, and nasopharyngeal carcinoma. Compared to the Hu-HSC model, the Hu-PBL model can generate high levels of T cells, making it an excellent model for studying mature effector T cells. However, due to the rejection of human T cells by mouse immune cells, this model is susceptible to graft-versus-host disease (GVHD), leading to a shortened lifespan of the mice and limiting the duration of research.

**Zebrafish Model**

In recent years, the zebrafish cancer model has emerged as a promising vertebrate model. Zebrafish genomes exhibit homology and conservatism with humans, offering a solid foundation for studying various cancer developments. Compared to commonly used mouse models, the zebrafish model boasts unique advantages in cancer research: small size, low cost, and rapid reproduction. Additionally, zebrafish embryos are transparent, facilitating real-time observation and tracking of cancer cell proliferation, spread, and metastasis. Furthermore, transgenic and immunodeficient zebrafish can maintain transparency even into adulthood, simplifying gene operations and enabling quick establishment of transgenic animal models. Currently, various zebrafish cancer models have been established using techniques such as transgenic approaches, genome editing, xenotransplantation, and drug-induced toxic damage.

**Zebrafish Melanoma Model**

Melanoma, a highly malignant tumor derived from melanocytes, poses significant challenges in skin cancer treatment. Recent advancements in understanding the molecular mechanisms of melanoma invasion, proliferation, and metastasis have led to notable progress in melanoma treatment. By interacting with the microenvironment, melanoma cells achieve rapid growth and metastasis, underscoring the importance of establishing zebrafish melanoma models for studying melanoma pathogenesis and anti-melanoma drugs. Researchers, such as Dovey et al., have utilized transgenic technology to construct

zebrafish models expressing NRAS Q61K, demonstrating how the loss of p53 and NRAS expression promotes melanoma development. Other studies, like that by Fornabaio et al., have injected melanoma cells into zebrafish embryos to establish the first zebrafish model of melanoma angiogenesis and extravascular migration. Additionally, research by Gomez-Abenza et al. has shed light on the role of Spint1a in melanoma, providing insights into potential melanoma treatments.

**Zebrafish Leukemia Model**

The similarity between zebrafish and human hematopoietic systems has prompted the increasing use of zebrafish to simulate leukemia. Establishing zebrafish leukemia models is crucial for understanding the occurrence, development, and drug research of human leukemia. Researchers, such as Langenau et al. and Gutierrez et al., have leveraged transgenic zebrafish and induced acute T-lymphoblastic leukemia using specific genetic manipulations. Successful establishment of leukemia zebrafish models, as demonstrated by Corkery et al., has paved the way for targeted inhibitor intervention experiments, contributing significantly to leukemia research. Through these studies, researchers have gained deeper insights into leukemia pathogenesis and have identified various anti-leukemia drugs.

**Zebrafish Digestive Tract Tumor Model**

Digestive tract tumors present challenges due to disease concealment, difficulty in early diagnosis, and lack of effective treatment options. Understanding the molecular mechanisms of digestive tract tumorigenesis and identifying new drug therapy targets are critical research focuses. Although zebrafish lack stomach-specific genes, they exhibit high similarity with humans in gastric cancer cells, making them valuable for studying gastric cancer. Researchers, like Tsering et al., have established zebrafish gastric cancer xenotransplantation models to investigate potential treatments, such as Triphala. Additionally, zebrafish liver cancer models have provided insights into hepatocellular carcinoma pathogenesis and potential therapeutic targets. Through the establishment of zebrafish pancreatic cancer xenotransplantation models, researchers, such as Guo et al., have identified novel therapeutic drugs, highlighting the feasibility of zebrafish models in drug screening and therapeutic development for pancreatic cancer.

**Humanized Patient-Derived Xenograft (Hu-PDX) Model**

The Hu-PDX model involves the reconstruction of the immune system in severely immunodeficient mice (such as NOG or NSG mice) to mimic the state of normal individuals or clinical patients. Subsequently, human tumor tissue blocks are orthotopically transplanted into these immune system-humanized mice, resulting in the Hu-PDX model. This model offers a growth environment more akin to that of the human body for tumors, holding significant value in tumor treatment and the investigation of tumor occurrence, development, and metastasis, particularly in tumor immunotherapy.

The Hu-PDX model has found applications in various tumor research endeavors. For instance, Lin established human immunodeficient mice by implanting peripheral blood lymphocytes and demonstrated the efficacy of PD-L1/PD-1 targeted cancer immunotherapy using a PBMCs-derived PDX model. Rosato showcased the feasibility of anti-programmed cell death-1 (PD-1) immunotherapy in triple-negative breast cancer (TNBC) studies through a PDX model derived from TNBC patients. Similarly, Sanmamed et al. injected lymphocytes from gastric cancer patients into immunodeficient mice, followed by the transplantation of gastric cancer tissue from the same patients into the mice. Subsequently, the mice were

treated with nivolumab (a PD-1 inhibitor) and urelumab (an anti-CD137 agonist), revealing that these drugs could induce self-T cell attack and decelerate tumor growth.

However, the current Hu-PDX model faces certain challenges, such as a low modeling success rate, short duration of humanized immune system existence, and incomplete immune function. Future research endeavors should concentrate on enhancing humanized mouse modeling techniques and improving the efficiency and longevity of immune system implantation.

**Patient-Derived Orthotropic Xenograft (PDOX) Model**

The conventional sites of transplantation in the PDX model, mainly subcutaneous or renal capsules, lack the in situ environment necessary for tumor growth. It has been observed that orthotopically transplanting tumor tissue into animal organs corresponding to the primary site provides a more authentic in vivo environment for tumor growth. Hence, the PDOX model is established as an extension of the PDX model. In comparison to the traditional PDX model, the PDOX model offers a more objective and accurate simulation of the evolution of human tumors in vivo. For instance, Hiroshima et al. conducted a study involving 10 cases of subcutaneous injection PDX model and 8 cases of PDOX model using cervical cancer tissue. Their findings revealed tumor metastasis in half of the PDOX model cases but not in the PDX model cases. This underscores the PDOX model's superior ability to demonstrate the biological characteristics of malignant tumor invasion and metastasis compared to the PDX model.

Several studies have highlighted the influence of the organ microenvironment on the biological characteristics of tumor growth. The PDOX model has demonstrated the capability to accurately predict cancer patients' prognosis and aid in selecting the most suitable individualized treatment. For instance, Hiroshima et al. conducted another study where they established both PDOX and subcutaneous PDX models of human cervical cancer and treated them with entinostat (a benzamide histone deacetylase inhibitor). Interestingly, they found that only tumor growth was inhibited in the PDOX model. However, due to the predominantly in vivo location of tumors in the PDOX model, traditional detection methods struggle to accurately monitor tumor growth and identify metastatic foci. Hence, developing a PDOX model that allows for easy measurement poses a challenge for future research endeavors.

**Mini Patient-Derived Xenograft (Mini-PDX) Model**

The Mini-PDX model serves as a drug sensitivity testing model established through a unique approach of transplanting human tumor tissue into immunodeficient mice. This method involves first injecting the digested cell suspension of the patient’s tumor tissue into microcapsules, which are then transplanted into the mice. For instance, Zhan et al. established a Mini-PDX model using tumor tissues from patients with gallbladder cancer to assess the sensitivity of the five most commonly used chemotherapeutic drugs: gemcitabine, oxaliplatin, 5-fluorouracil, nanoparticle albumin-bound (nab)-paclitaxel, and irinotecan. Their findings revealed relatively low proliferation rates of gallbladder cancer cells in the model following treatment with irinotecan and gemcitabine.

This model offers several advantages for drug sensitivity testing, including shorter duration, lower costs, and high consistency with the results of the traditional PDX model. Zhang et al. further expanded the application of Mini-PDX models to lung cancer, gastric cancer, and pancreatic cancer, using the PDX model as a reference to test drug sensitivity. They found a remarkable consistency of 92% between the results of drug sensitivity testing using the Mini-PDX model and the traditional PDX model, albeit with significantly shorter time requirements for the former. This underscores the potential of the Mini-PDX

model as a viable substitute for the PDX model in evaluating cancer treatment efficacy. Given its advantages, the Mini-PDX model holds promise as a tool to facilitate personalized treatment for cancer patients.

**Surgical Techniques and Procedures in Minimally Invasive Surgery and Traditional Surgery**

Minimally invasive surgery can be defined as a safe procedure associated with lower postoperative morbidity compared to conventional approaches for the same operation. The advent of minimally invasive surgery dates back to the early 20th century when cystoscopy was first used to examine and treat bladder lesions. This paved the way for arthroscopy, introduced in 1931 by Takagi of Tokyo, which later evolved into a preferred method for diagnosing and treating knee maladies. Since then, minimally invasive surgery has witnessed significant advancements and is projected to account for over 80% of all surgical procedures in the future, with most being performed on an outpatient basis.

Physicians and surgeons advocating for minimally invasive surgery are actively exploring its efficacy, driven by constant improvements in surgical instruments. While these advancements enhance procedural ease and effectiveness, surgeons must undergo a learning curve to master the new technology, bearing in mind potential risks. Despite the semantic debate surrounding the term 'minimally invasive surgery,' its widespread acceptance is justified by reduced operative trauma without compromising therapeutic benefits.

The success of minimally invasive surgery owes much to technical advances and operator skill. However, converting an endoscopic surgical procedure into an open surgical procedure requires clinical judgment and experience. Collaboration across disciplines is crucial for maximizing the potential of minimally invasive techniques. Furthermore, advances in video-assisted surgery and robotic manipulation present promising avenues for future developments in cardiac surgery.

Traditional open surgery, characterized by large incisions, remains necessary for procedures such as organ transplants and the placement of supportive devices like stents. However, with advancements in surgical methodology, minimally invasive surgery has become increasingly prevalent, offering less invasive alternatives with potential benefits in terms of patient recovery, postoperative care, and cost-effectiveness."

**Less Invasive Cancer Surgery Techniques**

**Laser surgery**

Laser technology offers a potent and precisely focused light beam, which serves as a valuable tool in surgical procedures. This advanced technique can replace traditional scalpels for tissue cutting and is effective in treating various cancers affecting areas like the cervix, penis, vagina, vulva, lung, and skin. Additionally, lasers can be utilized to vaporize tumors or precancerous growths.

Despite the initial impression of harm associated with laser burning, laser surgery proves to be less invasive compared to conventional methods, resulting in reduced cutting and tissue damage. Through the use of fiber optics and specialized scopes, lasers can be directed with precision through natural body openings, eliminating the need for major incisions. This targeted approach facilitates the precise removal of cancerous cells.

Moreover, lasers play a crucial role in procedures such as photocoagulation or photoablation, where they are employed to seal blood vessels or eliminate tissue. These techniques are particularly beneficial in

alleviating symptoms caused by large tumors obstructing the esophagus or windpipe, thereby improving swallowing and breathing function.

**Cryosurgery**

Cryosurgery involves the freezing and destruction of abnormal cells using either a liquid nitrogen spray or an extremely cold probe. This technique is commonly utilized to treat precancerous conditions affecting the skin, cervix, and penis, and can also be effective in managing certain cancers such as those found in the liver and prostate. By utilizing imaging scans like ultrasound or CT scans to guide the placement of the probe, the procedure minimizes damage to surrounding healthy tissue.

**Electrosurgery**

Electrosurgery employs a high-frequency electrical current to eliminate cells, often utilized in treating certain skin and oral cancers.

**Radiofrequency ablation**

Radiofrequency ablation (RFA) utilizes high-energy radio waves delivered through a needle to heat and eradicate cancer cells. This method, categorized under hyperthermia treatments, is effective in targeting tumors in organs such as the liver, lungs, and kidneys.

**Mohs surgery**

Mohs micrographic surgery, also known as Mohs surgery, is a meticulous procedure where thin layers of tissue are shaved off one at a time to eradicate specific types of skin cancer. Each layer is meticulously examined under a microscope for the presence of cancerous cells, and the process is repeated until all layers show normalcy.

**Laparoscopic surgery**

Laparoscopic surgery involves the use of a thin, flexible tube called a laparoscope to visually inspect the body through a small incision. Occasionally, this technique is employed in biopsies for cancer testing. Recent studies have demonstrated that certain tumors can be removed using laparoscopic methods, involving small punctures and specialized long, thin instruments. This approach reduces post-operative pain and blood loss, accelerates recovery, and shortens hospital stays. Nowadays, laparoscopic surgery is widely adopted for various procedures.

Doctors can safely and effectively perform laparoscopic procedures for certain tumors affecting the colon, rectum, liver, prostate, uterus, and kidney. Ongoing research is exploring the potential applications of laparoscopic techniques for other types of cancer.

**Thoracoscopic surgery**

Thoracoscopic surgery involves making a small incision in the chest after collapsing the lung, allowing the insertion of a thin tube called a thoracoscope equipped with a miniature video camera. This enables the doctor to visually inspect the chest cavity. The procedure facilitates the removal of small tumors from the lung's surface, drainage of fluid from problematic areas on the chest wall lining, and collection of tissue samples. This approach necessitates minimal cutting and has even been utilized for the removal of

cancerous sections of the lung. Studies indicate comparable outcomes between this method and traditional chest incision surgery for treating early-stage lung cancer.

**Robotic surgery**

Robotic surgery involves the use of precise robotic arms controlled by the surgeon during laparoscopic or thoracoscopic procedures. This approach offers similar benefits to laparoscopic and thoracoscopic surgery, including reduced post-procedure pain and blood loss, shorter hospital stays, and accelerated recovery. Robotic surgery is sometimes utilized in the treatment of uterine, colon, and prostate cancers.

**Stereotactic radiation therapy**

Stereotactic radiation therapy represents a new frontier in radiation treatment, blending traditional approaches with enhanced control over energy waves. Unlike conventional surgery, this technique doesn't involve any incisions but relies on highly precise delivery of radiation, often referred to as stereotactic radiosurgery due to its pinpoint accuracy. Equipment such as CyberKnife and Gamma Knife are used to administer this treatment, which targets a specific tumor area with a substantial dose of radiation from various angles. While commonly used for brain tumors, stereotactic radiation therapy can also be applied to tumors in the head, neck, lung, spine, and other regions.

**"Minimally Invasive or Traditional?"**

Choosing between minimally invasive and traditional surgical techniques relies heavily on thorough imaging during both preoperative and operative phases. X-rays, CT scans, and MRIs are commonly employed postoperative imaging methods for the spine, selected based on patient symptoms and initial surgical approach. The choice of postoperative imaging modality is determined by factors such as disease extent and clinical presentation. Accurate imaging plays a pivotal role in assessing complications, evaluating instrument positioning, fusion status, and decompression success. In managing ambiguous tumors, imaging is indispensable for determining whether traditional surgery or minimally invasive methods are appropriate. The following outlines how imaging aids in this decision-making process:

**Tumor Localization and Characterization:**

Imaging modalities like PET scans, CT scans, and MRIs provide detailed information on tumor characteristics, location, and size. Surgeons utilize this data to evaluate the feasibility of minimally invasive procedures considering factors such as tumor size, depth, and proximity to vital structures.

**Assessment of Tumor Spread:**

Imaging helps in assessing the extent of tumor spread beyond what is evident through physical examination. This information guides decisions on whether standard surgery is necessary to ensure complete tumor removal with minimal risk of residual malignant tissue, or if minimally invasive procedures are appropriate.

**Evaluation of Surrounding Anatomy:**

Imaging reveals anatomical features such as blood vessels, nerves, and organs, enabling surgeons to plan surgery techniques that preserve vital structures and minimize collateral damage.

**Real-time Guidance during Surgery:**
Advanced imaging techniques such as image-guided navigation systems and intraoperative MRI or CT scans allow surgeons to visualize tumors and surrounding structures in real time during surgery. This reduces the risk of harming adjacent healthy tissues and ensures precise tumor removal.

**Assessment of Response to Neoadjuvant Therapy:**
Imaging helps evaluate tumor response to neoadjuvant therapy (e.g., radiation or chemotherapy) before surgery. This information guides decisions on the extent of surgical resection required and the continued suitability of minimally invasive procedures.

**Postoperative Surveillance:**
Imaging is essential for monitoring any signs of complications or tumor recurrence after surgery. Regular imaging surveillance facilitates early detection of metastases or recurrences, enabling prompt intervention.

## Conclusion

A critical focus in modern surgical oncology revolves around comparing minimally invasive and traditional surgery for specific tumor types. Over the years, advancements in technology, surgical expertise, and accumulating clinical data have transformed the landscape of surgical interventions for various cancers. As we conclude this analysis, it's evident that choosing minimally invasive procedures over traditional surgery is a multifaceted decision, considering tumor characteristics, patient factors, and surgical objectives.

In oncologic surgery, minimally invasive approaches such as robotic surgery, laparoscopy, and endoscopic procedures are gaining popularity. The allure of reduced surgical trauma, shorter hospital stays, quicker recovery times, and potentially better cosmetic outcomes makes them appealing, especially for individuals grappling with tumors or cancers, where surgery can significantly impact physical and mental well-being. Additionally, across diverse cancer types, minimally invasive techniques have demonstrated comparable oncologic outcomes to traditional surgery, assuring patients and physicians of their effectiveness in achieving tumor control and long-term survival.

One distinguishing feature of minimally invasive procedures is their ability to provide surgeons with enhanced visualization and precision in the operating field. Utilizing articulating equipment, magnification, and high-definition imaging systems, surgeons can navigate complex anatomical structures more adeptly, facilitating meticulous tumor removal with minimal damage to surrounding healthy tissues. The advent of robotic-assisted surgery has revolutionized the field, offering surgeons exceptional maneuverability and intuitive control, thereby enhancing the safety and feasibility of minimally invasive techniques across various tumor types.

However, it's essential to acknowledge that tumor characteristics, anatomical location, and technical complexity can influence the effectiveness of minimally invasive procedures. While these methods have shown promise in treating certain cancers like colorectal, gynecologic, and early-stage prostate cancers, further research is necessary to ascertain their efficacy in managing tumors requiring extensive resection or in advanced disease settings. Challenges such as reduced tactile feedback, prolonged operative times, and the learning curve associated with new technology underscore the importance of careful patient selection and skilled surgical expertise to maximize outcomes from minimally invasive surgery.

Conversely, traditional open surgery remains a cornerstone of oncologic care, offering unparalleled tactile feedback, access, and adaptability in managing diverse tumor types and complexities. Traditional surgical techniques may offer distinct advantages in terms of exposure, tactile sensation, and the ability to address multifocal disease or anatomical variations in large or locally advanced tumors where complete resection and oncologic clearance are paramount. Moreover, open surgery retains its significance in scenarios necessitating extensive lymphadenectomy, visceral reconstruction, or concurrent organ resection.

In navigating the choice between minimally invasive techniques and traditional surgery, a nuanced understanding of tumor biology, patient preferences, and surgical proficiency emerges as pivotal determinants. While minimally invasive approaches present compelling advantages in terms of reduced morbidity, accelerated recovery, and comparable oncologic outcomes, their applicability may be tempered by technical constraints, tumor complexity, and the need for extensive resection. Conversely, traditional open surgery remains indispensable in addressing a diverse range of tumors and anatomical challenges, providing surgeons with unmatched access and versatility.

Looking ahead, the integration of innovative technologies, multimodal imaging, and collaborative decision-making frameworks will further refine our approach to surgical oncology, empowering clinicians to tailor treatment strategies and optimize outcomes for patients facing tumor or cancer diagnoses and treatments. By embracing a patient-centered ethos and leveraging the synergies between minimally invasive techniques and traditional surgery, we can chart a path toward a future where surgical interventions not only achieve clinical efficacy but also align with the holistic needs and aspirations of those we serve.

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