

## The Role of Minimal Invasive Injury in Chronic Disease Management

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### ABSTRACT

The 21st-century healthcare landscape is dominated by the escalating burden of chronic diseases, creating a pressing need for therapeutic strategies that bridge the gap between lifelong pharmacotherapy and radical surgery. This review explores the paradigm of therapeutic minimal invasive injury, a novel approach that employs controlled, localized insults to trigger beneficial systemic responses for chronic disease management. Moving beyond symptomatic management, these procedures—such as renal denervation for hypertension, endoscopic sleeve gastropasty for obesity, and duodenal mucosal resurfacing for type 2 diabetes—leverage the body's innate healing mechanisms to reset maladaptive physiological pathways. We examine the robust clinical evidence supporting the efficacy of these interventions across cardiovascular, metabolic, and oncologic diseases, highlighting their role in achieving durable disease modification, reducing morbidity, and improving quality of life. The mechanisms underpinning this approach, including immunomodulation, neuro-hormonal reprogramming, and the attenuation of systemic stress, are dissected to elucidate the link between localized injury and global therapeutic benefit. Therapeutic minimal invasive injury represents a fundamental shift towards recalibrating physiological set points, offering a potent and often superior alternative to conventional chronic disease management.

**Keywords:** Minimal Invasive Injury, Chronic Disease Management, Therapeutic Paradigm, Renal Denervation (RDN), Metabolic Surgery, Duodenal Mucosal Resurfacing (DMR).

### INTRODUCTION

The 21st-century healthcare landscape is overwhelmingly dominated by the relentless rise of chronic diseases. Conditions such as hypertension, type 2 diabetes mellitus (T2DM), obesity, metabolic dysfunction-associated steatotic liver disease (MASLD), and chronic obstructive pulmonary disease (COPD) constitute the leading causes of global morbidity, mortality, and healthcare expenditure.<sup>1</sup>

Traditional management paradigms for these conditions have largely revolved around an escalating ladder of care, starting with lifestyle modifications,

progressing to pharmacotherapy, and culminating, for a subset of refractory or advanced cases, in major surgical intervention. While medications can effectively manage symptoms and slow progression, they often require lifelong adherence and can be associated with significant side effects, cost, and variable efficacy.<sup>2</sup>

Major surgery, though potentially curative or highly effective for conditions like severe obesity or end-organ failure, carries substantial risks, including perioperative complications, prolonged recovery, and

permanent anatomical alterations, limiting its applicability to the most severe cases.<sup>3</sup>

This therapeutic gap between daily pill-taking and radical, irreversible surgery has catalyzed a profound shift in medical philosophy and practice. A new frontier is emerging, focused on interventions that occupy a middle ground: procedures designed to be minimally invasive, often outpatient, and which harness controlled, localized injury to catalyze systemic, therapeutic responses. This concept—therapeutic minimal invasive injury—represents a paradigm shift from managing disease to deliberately perturbing physiological systems to reset them towards a healthier state. The core principle is that a precisely delivered, limited insult to a specific organ, nerve, or tissue can trigger beneficial homeostatic, immunomodulatory, or metabolic adaptations that yield durable improvements in a chronic disease state. This review will explore the scientific rationale, clinical evidence, and future directions for this novel class of interventions across a spectrum of chronic conditions.

The biological foundation for this approach is rooted in the body's fundamental response to injury. Any breach of tissue integrity initiates a complex, orchestrated cascade involving inflammation, tissue repair, and remodeling.<sup>4</sup> The key insight is that by carefully controlling the nature, location, and extent of the injury, it is possible to steer this innate response toward a therapeutic outcome. For instance, a localized injury can activate immune cells that subsequently exert anti-inflammatory or pro-resolving effects systemically. Alternatively, injuring or ablating specific nerve fibers can disrupt maladaptive signaling pathways that sustain disease. This is not a new concept in all of medicine; the success of vaccination is predicated on a controlled immune stimulus to confer lasting protection. The novelty lies in applying this principle to the physiological dysregulation underlying non-communicable chronic diseases.

One of the most mature and compelling examples of this paradigm is Renal Denervation (RDN) for the treatment of resistant hypertension. Hypertension is a major driver of cardiovascular disease, and a significant number of patients fail to achieve blood pressure control despite multiple antihypertensive agents. The sympathetic nervous system, particularly the renal nerves, plays a critical role in blood pressure regulation via effects on renin release, sodium handling, and renal blood flow.<sup>3,5</sup>

Catheter-based RDN uses radiofrequency or ultrasound energy to selectively ablate these renal nerves through an intra-arterial approach. This minimal invasive injury to the perivascular nerves results in a significant and sustained reduction in sympathetic outflow. Multiple randomized, sham-controlled trials have now conclusively demonstrated that RDN leads to a clinically meaningful reduction in both office and 24-hour

ambulatory blood pressure, offering a durable device-based solution for a lifelong medical problem.<sup>6,7</sup> Here, the minimal injury is not to the organ parenchyma itself, but to its autonomic innervation, effectively "rebooting" a key regulatory circuit.

In the realm of metabolic disease, particularly T2DM and obesity, minimal invasive injury strategies are demonstrating remarkable efficacy. Metabolic surgery, such as Roux-en-Y gastric bypass, is the most effective treatment for severe obesity and T2DM, but its invasiveness and risks limit its use. The search for less invasive alternatives has led to procedures that mimic the effects of surgery through targeted injury. Endoscopic sleeve gastropasty (ESG), for instance, uses an endoscopically placed suturing device to remodel and reduce the size of the stomach, creating a restrictive pouch without any external incisions.<sup>8</sup> This controlled mechanical injury and remodeling of the gastric wall leads to significant weight loss and improvements in glycemic control, though the mechanisms extend beyond mere restriction to include alterations in gut hormone secretion.

Perhaps even more intriguing are procedures that target organs beyond the gastrointestinal tract. Endoscopic Duodenal Mucosal Resurfacing (DMR) involves the controlled hydrothermal ablation of the duodenal mucosa. The duodenum is increasingly recognized as a key signaling center in metabolic regulation. The injury induced by DMR is believed to trigger a reparative process that resets abnormal nutrient-sensing and insulin-signaling pathways in this region.<sup>9</sup> Clinical studies have shown that a single DMR procedure can lead to significant and durable improvements in glycemic control and hepatic insulin sensitivity in patients with T2DM, independent of major weight loss.<sup>9</sup> This suggests that the minimal injury to a specific tissue layer can systemically reverse aspects of metabolic dysfunction.

The concept extends to hepatology with the investigation of minimally invasive therapies for MASLD. While lifestyle modification remains the cornerstone, adherence is poor. Bariatric surgery improves MASLD, but its risk-profile is unjustified for liver disease alone. Consequently, procedures like gastric artery chemical embolization are being explored. The rationale is that a transient, targeted ischemic injury to a portion of the stomach (via embolization of the left gastric artery) may alter the production of hormones like ghrelin, leading to weight loss and metabolic improvement that benefits the liver.<sup>10</sup> Early-phase trials have shown promise, indicating that a vascular injury can produce a beneficial metabolic ripple effect.

The field, however, is not without its challenges and complexities. The "minimal" in minimal invasive injury is relative, and the risk-benefit ratio must be carefully evaluated for each procedure. Potential

complications, such as vessel dissection with RDN, stricture with DMR, or pain with gastric embolization, underscore the need for rigorous technical training and patient selection.<sup>11</sup> Furthermore, the long-term durability of these interventions and the potential for neural regeneration or physiological adaptation remain active areas of investigation. A deeper understanding of the precise molecular and cellular mechanisms linking the localized injury to the systemic therapeutic effect is crucial for optimizing these therapies and identifying the patient populations most likely to benefit. This review aims to examine the evidence for these innovative therapies, dissect their proposed mechanisms of action, and discuss the future trajectory of this exciting field as it seeks to redefine the standard of care for millions of patients living with chronic disease.

### **Impact of Minimal Invasive Techniques on Chronic Disease Outcomes**

In the realm of cardiovascular disease, particularly coronary artery disease (CAD), percutaneous coronary intervention (PCI) stands as a quintessential example of a MI technique revolutionizing outcomes.<sup>2</sup> Compared to the historical gold standard of coronary artery bypass grafting (CABG), PCI involves only a small incision, typically in the wrist or groin, to access the arterial system. Large-scale registry data and randomized trials have consistently demonstrated that PCI achieves rapid revascularization, reduces periprocedural mortality and myocardial infarction (MI) rates in the acute setting, and facilitates a much shorter hospital stay and recovery period.<sup>1,3</sup>

Beyond coronary disease, structural heart conditions like aortic stenosis have been transformed by MI techniques. Transcatheter aortic valve implantation (TAVI) has emerged as a life-saving procedure for patients with severe symptomatic aortic stenosis who are deemed at high or prohibitive surgical risk.<sup>5</sup> The landmark PARTNER trial showed that TAVI was superior to medical therapy and non-inferior to surgical aortic valve replacement in terms of mortality and functional status improvement. The outcome benefit is not merely survival; studies focusing on patient-reported outcomes show a dramatic and sustained improvement in QoL metrics, such as reduced symptoms of heart failure and increased physical functionality, within 30 days post-procedure.<sup>7</sup>

The field of oncology provides another compelling narrative for the positive impact of MI techniques. The diagnosis, staging, and treatment of cancer have been radically refined.<sup>8</sup> Image-guided biopsy techniques, such as computed tomography (CT)-guided core needle biopsies, have largely replaced open surgical biopsies for tissue diagnosis. These procedures are highly accurate, carry a minimal risk of seeding tumor cells, and are performed on an outpatient basis. For treatment, minimally invasive surgery, including laparoscopic and

robot-assisted techniques, has become the standard of care for numerous cancers. A seminal example is laparoscopic colectomy for colon cancer, which, compared to open colectomy, is associated with equivalent long-term oncological outcomes, but with the significant benefits of reduced blood loss, lower post-operative pain, shorter hospital stay, and earlier initiation of adjuvant chemotherapy.<sup>10</sup> This last point is critical; by enabling patients to recover faster, MI surgery ensures timely administration of systemic therapy, which is a crucial determinant of overall survival in oncology.

Furthermore, in the management of localized prostate cancer, robot-assisted radical prostatectomy offers superior precision in nerve-sparing, which directly translates to better preservation of urinary continence and sexual function post-operatively, drastically improving QoL outcomes without compromising cancer control.<sup>11</sup> Similarly, in thoracic oncology, video-assisted thoracoscopic surgery (VATS) lobectomy for early-stage lung cancer reduces post-operative complications and pain compared to open thoracotomy, allowing for a more robust patient state to withstand subsequent treatments.<sup>12</sup>

The impact of MI techniques extends deeply into metabolic and digestive chronic diseases. For morbid obesity, a major driver of type 2 diabetes, laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass are the cornerstone of effective long-term treatment. Numerous studies have shown that bariatric surgery leads to substantial, sustained weight loss and, most importantly, dramatic remission rates of type 2 diabetes, surpassing any available medical therapy.<sup>13</sup> The outcome is a reduction in overall mortality, cardiovascular events, and microvascular complications of diabetes.<sup>14</sup> For chronic gastroesophageal reflux disease (GERD), which can lead to Barrett's esophagus, laparoscopic Nissen fundoplication provides a durable solution where medical management fails, effectively improving symptoms and QoL.<sup>11</sup>

### **Mechanisms of Minimal Invasive Injury in Modulating Chronic Disease Progression**

The superior clinical outcomes associated with minimal invasive (MI) techniques are not serendipitous but are rooted in a fundamental modulation of the body's physiological and molecular responses to injury. By minimizing tissue trauma, MI approaches favorably alter the trajectory of chronic disease progression through several key interconnected mechanisms: the reduction of systemic surgical stress, the preservation of immune competence, the minimization of anatomical and functional disruption, and the direct interruption of specific disease pathways.<sup>13</sup>

A primary mechanism through which MI techniques exert their benefit is the attenuation of the systemic surgical stress response. Major open surgery

triggers a significant neuroendocrine-metabolic cascade characterized by the release of catecholamines, cortisol, and glucagon, leading to a catabolic state, insulin resistance, and fluid retention.<sup>14</sup> This response is directly proportional to the magnitude of tissue injury. MI techniques, by virtue of smaller incisions and less tissue dissection, markedly blunt this response. The clinical corollary is a reduced incidence of post-operative hyperglycemia in diabetic patients, less protein catabolism, and a lower risk of volume overload, which is particularly crucial for patients with compromised cardiac or renal function.<sup>15</sup> This mitigated stress response creates a more stable physiological milieu, allowing the patient to direct energy towards healing and recovery rather than combating the systemic effects of a major insult.

Closely linked to the stress response is the impact on the immune system. Major surgical trauma induces a state of systemic immunosuppression, increasing susceptibility to infections, and can also potentiate pro-inflammatory pathways that may adversely affect chronic disease.<sup>16</sup> Open procedures are associated with a significant rise in pro-inflammatory cytokines such as interleukin-6 (IL-6) and C-reactive protein (CRP). In oncology, this post-operative inflammatory state has been hypothesized to potentially create a permissive environment for the growth of residual micrometastases.<sup>17</sup> MI techniques, in contrast, result in a less pronounced inflammatory and immunosuppressive state. The reduced level of IL-6 and better preservation of cell-mediated immunity following laparoscopic surgery, for example, may contribute to the observed lower rates of post-operative septic complications and, in the cancer context, may theoretically translate to a lower risk of disease recurrence, though this remains an area of active investigation.<sup>18</sup>

The principle of anatomical and functional preservation is another critical mechanism. MI techniques are designed to target the pathology with precision, sparing surrounding healthy tissue. In cardiac surgery, a median sternotomy—the large incision for open-heart procedures—causes significant chest wall trauma, pain, and a prolonged period of diaphragmatic dysfunction. In contrast, transcatheter procedures like TAVI or MitraClip avoid this entirely, accessing the heart via peripheral vessels. This preservation of chest wall integrity prevents post-operative restrictive lung defects and enables immediate ambulation, which in turn reduces the risk of post-operative atelectasis and pneumonia.<sup>19</sup> Similarly, in abdominal surgery, laparoscopic techniques minimize disruption to the abdominal wall musculature and prevent prolonged exposure and handling of the viscera, which reduces the formation of adhesions—a common cause of long-term morbidity, including chronic pain and small bowel obstruction.<sup>13</sup>

At a molecular level, MI techniques can directly interrupt the pathophysiology of chronic diseases. The most striking example is in metabolic surgery. Procedures like Roux-en-Y gastric bypass and sleeve gastrectomy do not merely work by restriction or malabsorption; they actively modulate the enteroendocrine axis. These procedures alter the secretion of gut hormones such as glucagon-like peptide-1 (GLP-1), peptide YY (PYY), and ghrelin, leading to improved insulin sensitivity, enhanced satiety, and beta-cell function restoration independent of weight loss.<sup>14</sup> This hormonal reprogramming effectively puts type 2 diabetes into remission by targeting its core metabolic defects, a mechanism that is uniquely achieved through this form of controlled, minimally invasive injury to the gastrointestinal tract.

Furthermore, in interventional pain management, techniques like radiofrequency ablation (RFA) work by using thermal energy to selectively denature specific sensory nerves responsible for transmitting pain signals from arthritic facet joints or sacroiliac joints. This precise lesioning provides long-term relief from chronic musculoskeletal pain by breaking the cycle of nociceptive input, thereby modulating the central sensitization that often perpetuates the chronic pain state.<sup>15</sup> This targeted ablation spares patients the systemic side effects of long-term opioid therapy and avoids the morbidity of a major spinal fusion surgery.

## **Efficacy of Minimal Invasive Approaches in Chronic Disease Management**

The adoption of any medical technique is ultimately contingent upon the robust demonstration of its efficacy. For minimal invasive (MI) approaches in chronic disease management, efficacy is a multi-faceted concept, encompassing not only traditional survival metrics but also procedural success, disease-specific outcomes, functional recovery, and long-term durability. The evidence base, built upon randomized controlled trials (RCTs) and large registries, consistently affirms the high efficacy of these techniques across a spectrum of chronic conditions, often establishing them as the preferred standard of care.<sup>17</sup>

### **1. Cardiovascular Disease: A New Standard of Care**

The efficacy of MI techniques in cardiovascular disease is unequivocal. In coronary artery disease, percutaneous coronary intervention (PCI) with drug-eluting stents is highly effective for alleviating angina symptoms and managing acute coronary syndromes. Its efficacy in improving survival compared to medical therapy alone is well-established in patients with ST-elevation myocardial infarction and high-risk unstable angina.<sup>18</sup> Large-scale RCTs have demonstrated that for multi-vessel disease, PCI achieves comparable long-term mortality rates to coronary artery bypass grafting (CABG)

in select patient populations, while offering the unequivocal benefits of reduced procedural morbidity and faster recovery.<sup>19</sup>

In valvular heart disease, the efficacy of transcatheter aortic valve implantation (TAVI) has been transformative. The PARTNER 3 and Evolut Low Risk trials proved that TAVI is non-inferior, and in some endpoints superior, to surgical aortic valve replacement in low-risk patients for the composite endpoint of death, stroke, or rehospitalization at two years.<sup>20</sup> This established TAVI as an effective and often preferred treatment for severe aortic stenosis across all surgical risk categories. Similarly, transcatheter edge-to-edge repair (e.g., MitraClip) has shown efficacy in reducing hospitalization and mortality for patients with significant symptomatic primary and secondary mitral regurgitation who are high-risk for surgery.<sup>21</sup>

## **2. Oncologic Surgery: Equivalent Cancer Control with Superior Recovery**

In surgical oncology, the efficacy of MI techniques is measured by oncologic safety—specifically, long-term survival and cancer recurrence rates. For colorectal cancer, multiple RCTs, including the COST and COLOR trials, have conclusively shown that laparoscopic-assisted colectomy is non-inferior to open surgery in terms of overall survival, disease-free survival, and cancer-related mortality.<sup>22</sup> The efficacy of the MI approach is further enhanced by its association with lower short-term morbidity, which can facilitate earlier administration of adjuvant chemotherapy, a critical factor for overall survival.

In prostate cancer, robot-assisted radical prostatectomy provides equivalent efficacy to open surgery in achieving negative surgical margins and biochemical recurrence-free survival. Its superior efficacy lies in significantly better functional outcomes, including higher rates of urinary continence and erectile function preservation, which are crucial quality-of-life metrics for patients.<sup>17</sup> For lung cancer, VATS lobectomy has been proven to be oncologically equivalent to open thoracotomy for early-stage disease, with meta-analyses confirming no difference in long-term survival while consistently demonstrating superior efficacy in reducing post-operative complications, pain, and hospital length of stay.<sup>23</sup>

## **3. Metabolic and Digestive Diseases: Durable Disease Remission**

The efficacy of MI bariatric and metabolic surgery is profound, offering the most effective and durable treatment for severe obesity and type 2 diabetes. The Swedish Obese Subjects study, a landmark matched cohort trial, demonstrated sustained weight loss of 15-25% over 20 years, an outcome unattainable with non-

surgical interventions.<sup>24</sup> More importantly, its efficacy in inducing and maintaining diabetes remission is unparalleled. RCTs comparing surgery to intensive medical therapy have shown remission rates of 30-60% at 5-10 years for surgical patients, compared to 0-16% for medical management alone. This remission directly translates to superior efficacy in reducing microvascular and macrovascular complications.<sup>19</sup>

For chronic gastrointestinal conditions, laparoscopic anti-reflux surgery (fundoplication) demonstrates high efficacy in controlling GERD symptoms. Long-term follow-up studies show that over 90% of patients experience satisfactory relief of heartburn and regurgitation, with a reduced reliance on acid-suppressive medications, proving its durable efficacy over medical management in selected patients.<sup>22</sup>

## **4. Chronic Pain Management: Targeted and Sustainable Relief**

The efficacy of MI interventional procedures for chronic spinal pain is well-documented. Radiofrequency ablation of the medial branch nerves for facet joint-mediated pain provides effective relief, with numerous RCTs showing a significantly greater proportion of patients achieving at least 50% pain reduction lasting 6-12 months compared to sham or placebo interventions.<sup>23</sup> For chronic discogenic low back pain, intraosseous basivertebral nerve ablation has emerged as an effective MI treatment, with RCT data demonstrating statistically significant and clinically meaningful improvements in pain and disability scores at three months and one year compared to sham treatment.<sup>17</sup>

### **Reducing Morbidity:**

The primary advantage of minimal invasive (MI) techniques, and a core reason for their rapid integration into chronic disease management, is their profound capacity to reduce procedure-related morbidity. For patients with chronic illnesses, who often have diminished physiological reserves and multi-system involvement, the burden of a major therapeutic intervention can itself be a significant health event. MI approaches directly mitigate this burden by minimizing the initial injury, which cascades into a host of clinical benefits that accelerate and improve the quality of recovery.<sup>24</sup> This reduction in morbidity is manifested through several key pathways: diminished surgical site trauma, lower rates of systemic complications, and enhanced functional recovery.

### **1. Reduction in Surgical Site Morbidity and Pain**

The most direct mechanism by which MI techniques reduce morbidity is through the minimization of access-related trauma. Compared to the large incisions required for open surgery, MI procedures use small port sites or

natural orifices. This fundamental difference results in markedly less tissue dissection, muscle retraction, and nerve disruption.<sup>25</sup> The clinical translation is a significant reduction in post-operative pain. For example, patients undergoing laparoscopic cholecystectomy require substantially less opioid analgesia than those with open surgery, leading to a lower incidence of opioid-related side effects such as nausea, ileus, and respiratory depression.<sup>26</sup>

Reduced incision size and tissue handling directly lower the risk of wound-related complications, which are a major source of morbidity. The rates of surgical site infections (SSIs), wound dehiscence, and incisional hernias are consistently and significantly lower after MI surgery across multiple disciplines, from colorectal to bariatric procedures.<sup>27</sup> This is particularly crucial for diabetic or immunocompromised chronic disease patients, who are at inherently higher risk for infections. Furthermore, the superior cosmetic result, while often considered secondary, contributes to improved body image and psychological well-being, which is an important aspect of recovery in chronic conditions.<sup>25</sup>

## 2. Mitigation of Systemic Complications

The attenuated systemic stress and inflammatory response discussed previously have a direct impact on reducing major organ system complications. By blunting the catabolic response and reducing the release of inflammatory mediators, MI techniques protect end-organ function.<sup>28</sup>

- **Cardiopulmonary Complications:** The ability to avoid a large thoracic or abdominal incision and to reduce post-operative pain directly translates to a lower risk of atelectasis and pneumonia. This is because patients can breathe deeply and mobilize sooner. The reduced fluid shifts and inflammatory cascade also decrease the strain on the cardiovascular system, leading to a lower incidence of cardiac events such as atrial fibrillation and congestive heart failure in the post-operative period. Studies comparing video-assisted thoracoscopic surgery (VATS) to open thorotomy for lung resection have demonstrated a significant reduction in pulmonary and cardiac morbidity.<sup>29</sup>
- **Thromboembolic Events:** Early ambulation is a cornerstone of preventing deep vein thrombosis (DVT) and pulmonary embolism (PE). The minimal pain associated with MI procedures enables patients to get out of bed and walk within hours of surgery, dramatically reducing the period of stasis that predisposes to clot formation.<sup>30</sup>
- **Gastrointestinal Recovery:** The preservation of the abdominal wall and minimal handling of the

intestines during laparoscopic surgery results in a much faster return of bowel function. Post-operative ileus, a common and uncomfortable complication of open abdominal surgery, is significantly shortened, allowing for earlier resumption of oral intake and discharge from the hospital.<sup>27</sup>

## 3. Preservation of Functional Capacity and Faster Return to Baseline

For patients with chronic diseases, maintaining functional independence is a critical goal. Major open surgery often precipitates a significant and sometimes permanent decline in functional status, especially in the elderly or frail. MI techniques, by reducing the overall physiologic insult, excel at preserving functional capacity.<sup>31</sup>

The combination of less pain, fewer systemic complications, and shorter hospital stays allows patients to return to their normal activities of daily living (ADLs) and, if applicable, their workforce, much more rapidly. For a patient with chronic heart failure who undergoes TAVI instead of open surgery, the difference is between a hospital stay of 1-3 days versus 5-10 days and a recovery period of weeks versus months.<sup>32</sup> This rapid return to baseline is not merely a matter of convenience; it prevents the deconditioning, muscle loss, and loss of independence that can occur during prolonged recovery from a major operation. In oncology, this preserved functional capacity means patients are in a better state to receive adjuvant therapies on schedule, which is a key determinant of long-term survival.<sup>29</sup>

## 4. Impact on Specific Chronic Illness Populations

The benefits of reduced morbidity are magnified in specific patient cohorts:

- **The Obese Patient:** In this population, large abdominal incisions are prone to infection and dehiscence. Laparoscopic bariatric surgery drastically reduces these risks, making a life-changing intervention safely accessible.<sup>24</sup>
- **The Patient with Respiratory Disease:** For a patient with severe chronic obstructive pulmonary disease (COPD), the pulmonary compromise caused by a thorotomy or upper abdominal incision can be devastating. VATS procedures offer a viable surgical option with a manageable risk profile.<sup>29</sup>
- **The Frail Elderly:** This demographic has the least reserve to withstand a major surgical insult. MI techniques, by minimizing blood loss, pain, and metabolic stress, make definitive treatments feasible for conditions that would otherwise be managed palliatively due to unacceptably high surgical risk.<sup>31</sup>

## CONCLUSION

The therapeutic minimal invasive injury paradigm is a radical shift of the traditional approach to chronic disease management. It is no longer about the extrinsic modulation of symptoms using drugs or the permanent anatomical disfigurement of large surgery, but again a more subtle intervention that capitalises on the biological language of injury, repair and customisation already present in the body. As it has been described in this review, such procedures as renal denervation, endoscopic sleeve gastropasty, and duodenal mucosal resurfacing are not just the procedural novelties; they are the potent ones, which directly target the dysregulated physiological processes in the form of neural, hormonal, and metabolic processes that maintain such conditions as high blood pressure, diabetes, and obesity.

The effectiveness of this method which is now firmly supported by high level clinical evidence lies in the fact that it employs a localized and controlled insult as a stimulus to systemic benefit. These interventions cause maladaptive feedback loops to be disrupted and the homeostatic set points to be recalibrated towards a healthier set point by selectively damaging critical signaling centers, the renal sympathetic nerves, the gastric wall or the duodenal mucosa. The ensuing blood pressure, glycemic control, and body weight changes are not mere manifestations of symptoms but that of a more fundamental reestablishment of physiological balance.

## DECLARATIONS

### Ethics Approval and Consent to Participate

Not applicable. This is a review article and does not involve direct work with human or animal subjects or personal data.

### Consent for Publication

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### Authors' Contributions

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