



Dark side of the moon: the price to pay in minimally invasive thoracic surgery (MITS)

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Background: The undiscerning canon characteristic of minimally invasive thoracic surgery (MITS) is challenged from an unorthodox subjective viewpoint of an academic thoracic surgeon highly experienced in MITS and optimally invasive thoracic surgery alike with extensive relevant literature output.

Methods: A staging historical review of milestones of MITS is complemented by a subjective and arbitrary list of contemporary clinical questions regarding overextension of minimal invasiveness in thoracic surgery. Subsequent generations of surgeons and their surgical preferences are compared and dissected. The attitude of the surgical community towards stapler failures is questioned. Emerging dogmas concerning ideal and exclusive interventions for pneumothorax and inflammatory lung conditions are exposed.

Results: The historical analysis concludes in a three stages concept in the form of a skeletal framework. Stage I represents the pre-video enhanced surgery age lasting up through 1990 ca. Stage II consists of echelon 1 [prior to 2000] echelon 2 [2000–2010] and echelon 3 up through today. Stage III is yet ahead of us outfitted with resplendent adornments including remote controlled intracavitary tools supported by integrative image guidance. Non-stapled tissue fusion methods are to be game changers. Crucial components of the operative interactions undoubtedly need scrutiny. Focused cases of the surgeon, the stapler and the video-assisted thoracic surgery (VATS) procedures themselves are investigated including elements of mythology hovering over MITS and are dissected to the bones.

Conclusions: Surgical technique questions such as open thoracotomy procedure or MITS methods should be a matter of pure scientific and clinical consideration definitely not a sort of quasi religious conviction. Instead of minimizing surgical invasivity uncritically, optimization of surgical aggressivity is called for, in which operative technology plays an unquestionable crucial role, however its application cannot eclipse or even blur the ultimate aim of surgery: its benefit to the individual patient while serving the larger community—namely society.

Keywords: Minimally invasive thoracic surgery (MITS); video-assisted thoracic surgery (VATS); surgical philosophy; decision making; complications

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“The longer you can look back, the farther you can look forward.”¹

—Winston Churchill

“I transmit but do not create. I believe in and love the ancients.”²

—Confucius

Introduction

This is an unorthodox overview regarding problems surrounding minimally invasive thoracic surgery (MITS)

¹, Churchill by Himself, Appendix I: Red Herrings, ed. Langworth, PublicAffairs, 2008 p. 577 ISBN 1586486381;

², Analects Ch. 7, v. 1.

from an admittedly subjective viewpoint while playing the devil's advocate. Asymmetry represented in positive reports on MITS subjects and disturbing near absolute silence in different corners in formulating any doubts or caveats summons the author to a sort of coming out in a declaration urging rational reservations. Nothing is farther from the author of this unorthodox article than deny the importance of the technological progress in the art of surgery. On the contrary quite the opposite is true: my aim is to identify the mistakes committed during commercialization of key hole surgery, the gung ho approach and the rush in uncritical chase of novelty, purely for the exclusive sake of the novelty. There is a need for a critical attitude regarding the danger of naked technology hacking away and sometimes cancelling the standard considerate elements practiced in the art of surgery which of course, is imminent. More than forty years experience immersed in academic theory and daily practice in general thoracic surgery serves as an ample premise and excuse for the author to structurally challenge the trends forming the present canon in reference to so called minimal invasive procedures. This is the final bugle call from the trenches, and admittedly, the author summons a sort of wish of provocation in order to get a less foggy and misty picture across regarding the future in which we are heading, the future we build and the future is going to be built around us including our trainees and disciplines.

Methods

Approach and modus operandi

The complexity and depth of the topic commands a deviation from the standard approach, therefore a chimera was conceived in which basic features of a narrative review are fused with the logic of an essay enforced by the safety net of references in order to achieve its aim: presenting a perspective from an unconventional angle at our state-of-art, contemporary form of MITS. Metaphors and similar stylistic forms are unavoidable yet hopefully pardonable tools in an intentionally debatable paper. The structure of this two parts analysis and autopsy serves as the roots—history (part one)—is followed up with elective yet conceptual look at the present (part two). All in order to depict an image of the future. The following is a structured attempt at creating a historic framework to understand the various undercurrents, thus far including unfocused issues regarding video-assisted thoracic surgery (VATS) which are itemized. The list is far from being complete and somehow

asymmetric, reflecting to the author's quite extensive past publication activity in reference to the topic. Consequently, there is an inherent danger of preselection bias. The reader is hereby warned.

View of the past: the background

Emergence of surgery as a sui generis invasive form of medicine

In the beginning the art of medicine under the aegis of the Greek semigod, Aesculapius (1) ruled. As early as in the age of Hippocrates, medical professionals were cautioned when treating patients by potentially injuring bodily integrity, not to mention extracting stones (2). Notably, the self respecting physician avoided in spilling blood and consequently surgery became a second-class profession among healers with rare exceptions of military barbers of the courts. It was not until the advent of 20th century when surgery became the queen of the battlefield culminating in the proverb: this is the century of surgery (3). In the last decade of the second millennium the eye and the palpating finger of the surgeon were challenged by the object lens of the camera and reality became increasingly virtual. The new age of video assisted surgery or key hole procedure arrived. Generations of old school surgeons were challenged by the cresting wave of new technology and the media driven public, actually paying the treatment bill in different and divergent meanings of the word, became mesmerized. The market-friendly expression “minimally invasive” as opposed to the supposedly reckless and unnecessarily aggressive, “maximally destructive open surgery” became a trending buzzword and was soon elevated up onto the pedestal of mantra.

Here we are in the third decade of the 21st century, the first quadrant is nearly over and the motto of surgery is “to be as minimally invasive as possible and pain-free over all”. Millimeters of incisional scars are measured as badge of honour of the individual surgeon, no matter what happened “inside”. Medicine in general and surgery in particular, once a respected profession serving the few who were able to afford it, became a public commodity by the second half of the past century. The patients of bygone years are transfigured now to clients and surgical operation, now “youtubed”, is a special service not much different as mending a broken down car or performing highly sophisticated plumbing. However no one suggests a plumber or a car mechanic to act “as minimally invasive as possible”. All sensible consumers only crave for a properly

working automobile and an end to a leaky faucet. Similarly, surgical aggressivity should be optimally invasive with regard to any procedure, chest surgery included in order to regain health and/or provide comfort if curing is beyond hope. In fulfilling this noble task we have to be honest to our patients, those who cover the bill and to ourselves as professionals.

MITIS: historical time line

Distant past (Stage I; Epoch O: early 1900s–late 1980s)

History is a tool to understand the present. To visualise the road on which we transverse and where we are right now, while counting the milestones along the road we can see how traditional chest surgery inevitably was transfigured.

The origo of exploration regarding thoracic cavity via a rigid scope for direct vision is disputed. Anecdotic reports referencing occasional intrathoracic applications of cystoscopes preceded the standardized and established form of intraabdominal and intrathoracic delivery of a tube-optic complex extended by manipulators what the historical consensus attributes to Jacobaeus (4). Notably Josef Grünfeld's paper is the first report regarding endoscopic examination of the chest cavity using a binocular device in 1879 in Wien, an experiment followed by many others in a chain of contributors in the following three decades (5,6).

Thoracoscopy and pneumolysis become a standard procedure during the age of tuberculosis, as freeing pleural adhesions were the *sine qua non* in creating artificial pneumothorax, the most frequent and preferred surgical treatment in treating tuberculosis up through the advent of Streptomycin (7). The procedure was practiced and much refined during the mid-20th century and evolved from extracting tissue biopsies and fluid samples for diagnosis under direct visual control into therapeutical procedures of evacuation. Medical thoracoscopy—a procedure under local anesthesia—was preferred by the pneumonologists. Surgeons having the luxury of general anesthesia performed more extensive adhesiolysis, an increasing number of biopsies of parietal and even visceral pleura, of which led to the exploration of the mediastinum.

Collar mediastinoscopy pioneered by Carlens (8) and its parasternal equivalent Stemmer/Chamberlain procedures were frequently performed in the 1970s and 1980s are *sui generis* referencing an early form endoscopic surgery. Their omission from the historical canon of MITIS might be explained by the direct visual control of the original methods. Surgeon-led MedTech innovations

(Lerut, Hürtgen, Linder-Dahan, Zielinsky) resulted in the multipotent video-mediastinoscopes in the 1990s (9,10), tools opening up the road to present day video-assisted mediastianl lymphadenectomy (VAMLA) (11).

Game changers: optical cables, monitors and staplers

The visual signal transmission and projection of the view on a TV screen, later referred to simply as monitor, led to the paradigm shift in the world of natural orifice endoscopies in the 1980s. Direct vision was replaced by Hirschowitz's fiberoptic cables and in the ensuing twenty years flexibility increased and tube diameters were reduced. Both cavities representative of the human torso were now accessible and a trove of procedures under video control as the gynecological application evolved into surgical laparoscopy. Very soon after the first video cholecystectomy in 1988 (12) thoracic surgeons rediscovered their heritage and rebooted their magic weapon. Televised images of pleural abnormalities called for biopsy and removal if size permitted (13). While intraabdominal procedures were made available by the insufflation using Veress-needle, invented for treating tuberculosis by creating pneumoperitoneum back in 1936 (14), lung collapse resulting in free space for manipulation was offered by the separated lung ventilation by Carlens and White tracheobronchial tubes, replaced soon thereafter by the now ubiquitous Robertshaw tubes (15).

The introduction of the laparoscopic version of the staplers based on the Hüttl-Petz concept (16) developed further by the Russian staplers of the 1950s (17) and popularized as an indispensable surgical tool by Ravitch among others (18) led to safe lung parenchyma resections in the early 1990s.

The stage for the advent of the VATS was set: all the procedures and their tools are on the scene by the last decade of the 20th century (19,20). VATS did not enter the ring much in the way Pallas Athene in full armor, yet all the requisites made their own exclusive contribution resulting in a dynamic synergic effect.

Present continuous: Stage II: Epochs 1–3

An arbitrary periodization describing the evolution of MITIS

Epochs 1–3 spanning the era beginning in 1990 up through present day 2022 are peremptorily periodized according to the assumption in which each segment differs from the previous one and in a distinctive, significant manner. However, transitions are without sharp divisions and dates generally overlap one another. It does not make sense to open fruitless priority debates fuelled by vanity and pride.

The aim is to provide an overall picture of when a certain procedure became the standard of care. Geographic region specific differences remain open for debate as far as Europe, USA or the Far-East are concerned.

Epoch 1

From 1990 onwards rod thoracoscopy transformed into televised imaginery shot by camera and within one or two years following now with the advent of chopstick-style manipulators the method stepped over the competencies of pleural biopsy and adhesiolysis entering the until then no-go zone regarding lung parenchyma samplings (19,20) and even limited resections (21,22).

Ever the standard, the trocar size 12 mm or larger, along with surgical staplers underwent modifications resulting in extended and articulated shafts including improved rod and cog transmissions. Johnson & Johnson's Ethicon and Auto Suture of the United States Surgical Corporation two major players and prominent contemporary manufacturers of surgical equipment were in a neck and neck development and innovation race. MITS procedures involved evaluation of mediastinal adenopathy, pleural effusions (23), biopsy of indeterminate pulmonary nodules (non-anatomical) atypical wedge resection of benign lesions of the lung or malignant cases when impaired cardiopulmonary reserves did not allow lobectomy. These predominantly diagnostic procedures quickly evolved into established procedures and were adopted and accepted as the standard of care (24). The concept regarding VATS lobectomy was proven, however its oncologic correctness remained questionable even in Stage I non-small cell lung cancer (NSCLC) (25). Serious doubts regarding proper nodal staging (N of TNM system) formed the main objection in the acceptance of the method as a standard choice in lung cancer surgery (26).

Epoch 1 witnessed the emergence of pneumothorax surgery and bullous disease. Lung volume reduction surgery, a reborn procedure as a bridging operation to lung transplantation offered a new field for VATS from the middle decade (27). Non-lung thoracic surgery open for MITS included pericardial window, and mediastinal procedures in the posterior and anterior (thymectomy) mediastinal masses and dorsal sympathectomy. Upper gastrointestinal (GI) and thoracic surgery shared interest in distal esophageal lesions offered another option.

Epoch 2: the new millennium

TNM centered lung cancer surgery experienced two significant achievements in the first decade of the new millennium. Neoadjuvant therapy followed by resective surgery became fully established (28), while the

feasibility regarding VATS lung resection as a standard procedure in all lung cancer surgeries still found the jury in contemplative deliberation. The oncoteam/multidisciplinary team mentality resplendent of the decade increasingly requested detailed surgico-pathological reports regarding the hilar/mediastinal lymphnode status, a demand suboptimally fulfilled by VATS. While N-stage mapping was well established for open procedures, MITS methodology and instruments have been suboptimal for responding to challenges regarding ordinary surgeons of the age. From a technical point of view, the surgical port number magic fight took root (29). The decade bore witness to the initiation of the port-number competition. The original three-port approach was challenged by the newly emerging single port approach (30). An interesting geographico-mental phenomenon, the Latin surgical schools pioneered the process, among others including the Spaniard Diego Gonzales Rivas, the Italian Gaetano Rocco (31) and Marcello Migliore (32). The challenge of the classic surgeon's position operating from the back of the patient lying in a lateral decubitus position by the anterior approach (33) was both technical and symbolic at the same time. Seemingly minor technical aspects, such as the Alexis-ring, developed originally for wound protection during septic abdominal surgery ensured safe removal of the VATS specimen and protected tumor seeding (34). Articulated endostaplers with built in cutting function modified our classic, fissure centered lobectomy concepts, as the new fissureless technique allowed quick and safe access to the hilar structures (35,36). Energy devices (bipolar, monopolar and ultrasonic) marketed as the Ligasure and Harmonic Scalpel including their alterego derivatives delivered sheer power in support of vessel sealing (37,38) challenging the mechanical closure methods using rows of staples. The Nuss procedure (initial take-off dating back to 1987) offered a paradigm shift in the majority of routine pectus surgeries and more than a decade later it was recognized as the gold standard (39). VATS in classic fields of thoracic surgery such as thoracic empyema was limited to evacuation (Stages I and II) (40) as the lack of free pleural space prevented effective decortication during Stage III processes. Transdiaphragmatic pericardioperitoneal shunting via laparoscopy was a new two-cavities video procedure (41).

By around 2010 there was an undeclared consensus (42,43), in which further progress regarding major lung resections required solving two major problems; proper lymphnode harvesting (44) and target identification (45). Suboptimal intraoperative nodal staging in light of the

IASCLC recommendations and insufficient detectability of small (<10 mm) intraparenchymal lung lesions deep below the surface needed tackling (46). While the surgeons hoisted the flag of minimally invasiveness up the mast, the anesthetists did the same. Awake thoracic surgery saw its pioneers leading to the reinvention of nonintubated anesthesia (47,48).

Epoch 3: 2010 to the present

The publication profile regarding the last decade proves, VATS became an established method in all domains of lung cancer surgery. Standardization protocols such as the Danish model (49) and others (50) contributed significantly to the progress. All levels of lung resections and standard lymphnode dissection via VATS became accepted standard procedures. Minimally invasive segmentectomy—a prime candidate for equal right choice for Stage One NSCLC by the early 2020s (51) won acceptance in spite of the technical ambiguity regarding the definition of intersegmental demarcation lines and uncertainties concerning orientation and target identification below a certain tumor size. The limits of the VATS/robot-assisted thoracic surgery (RATS) are currently undergoing permanent expansion towards more advanced cancer stages. In summary, all forms of parenchyma resection from wedge/segmentectomy through sleeve resections, including extended pneumonectomy all got the greenlight regarding the procedural lists of VATS (52). The full spectrum of operations involving the lung soon joined the already established procedures in reference to the pleura (empyema decortication included), diaphragm, pericardium, and mediastinum: consisting of tumours and cysts. Neurosurgery as an allied speciality joined forces with VATS procedures on autonomic nervous system (sympathectomy, Schwannomas, etc.) and anterior approach operations in combination with spine surgery. In consideration of the thoracic esophagus esophagectomy and related procedures, in occasional combination with laparoscopical harvesting of interpositums became an alternative however not an accepted norm (53). On the other side of the diaphragm, laparoscopy became the standard procedure in reflux surgery. Deliberate thoracic trauma applied MITS only in semi-elective monotrauma cases, as the time-factor and the “unknown patient phenomenon” prevented more general application.

Open thoracotomy lost its general gold standard position throughout Europe and the thoracic surgery centers in the USA at the end of the second decade in spite of more limited thoracotomy incisions (muscle sparing thoracotomy and axillary thoracotomy) and increased efficacy of

postoperative pain management and physiotherapy. No sensible researcher dared to submit papers referencing non-VATS approaches and no journal risked citation index values towards accepting such a scandalous report. Enhanced Recovery After Surgery (ERAS) became a magic bullet (54), as the consumerism (provider *vs* surgeon, client *vs* patient) prioritized time sparing “fast track” operations in direct contrast to patient safety. The port number contest settled down, fronts frozen: surgeons preference rather than proven superiority determined choice. Stapling devices perpetually developed (55) thus making dissection safer, especially with the introduction of angled tip staplers (56,57). Technical improvements in metal suture lines (58), and in manual control by motorized triggering (59,60) were challenged by the fusion efficacy of locally applied energies (61) resulting in control of bigger and bigger caliber vessels. The expectations promised by the magic light, laser of the 1980–1990s (62), were not fulfilled, and were replaced by the less ambitious but yet more reliable new energy devices (63).

While VATS was winning the hearts and minds of surgeons and contributed to the purse of healthcare management, it spied a challenger lurking in an unsuspected corner. It was robotic surgery (64), an eye wateringly expensive Behemoth of the early Da Vinci and later the ZEUS system (65) No one asked for it, but once robots arrived no one could resist its alluring temptations. The impressive Shiva-like complex soon became the object of desire, a heart throb and the symbol of excellence and privilege. Developed originally for pure military purposes (66) (remote surgery) an ideal drain of the resources and theater time consumer. With doubtful superiority in routine thoracic surgery at a procedural cost affordable only by the fortunate few, it is a dream toy for many of us. The magic unleashed is proven by numbers and economics might help. Da Vinci latest model, HUGO of Medtronic and Monarch associated with Johnson and Johnson are the tip of the iceberg regarding high tech development and artificial intelligence in the operational (OP) theater. Their general consolidation in the upcoming future is questionable, dependent upon budgetary factors rather than strictly professional dividends. It may be more understandable in examining robotic surgical systems in the function of a Forma-I racing car influencing the next generation of the Ford Fiesta or a Suzuki Vitara.

Stage III

This stage is ahead of us, and will very likely usher on intrathoracic image generators and various manipulating tools which are physically independent of the operator.

The targeted lesion is located without the need for haptic information and the traditional staplers are replaced by innovative tissue fusion technologies. The main question regarding this stage is affordability (robotics) and budget considerations. Once again, less medical than technologic and economic aspects above all. There is a more substantial question currently unanswerable but for the time being, beyond pure technicalities. Will resective procedures maintain their pivotal role in lung cancer treatment, or will emerging systemic treatments such as targeted and immunotherapy delegate surgery into a highly limited role? We saw it unfolding in the case regarding tuberculosis (7) and the recent stent-driven intervention profile change in reference to cardiovascular surgery (67) is a warning sign of dire straight up ahead. The emergence of non-surgical ablative procedures (68,69) such as stereotactic radiotherapy, radiofrequency, thermal and chemical ablation is another issue. Are they ousting the surgical approach or integrating into the operative (VATS/RATS) arsenal? A question poised to the imminent future. All these challenges fence-sitting on our horizon are reminders: surgery is a subset of the art of medicine with strong ties to medical engineering not the other way around.

Results

Looking at the facts

Having reviewed the main stages of the way which led us to where we find ourselves today (70), it is time to reorientate ourselves when 50–75% of all major procedures are performed using VATS/RATS in the thoracic surgical centers, it is time to look around where we are and where do we intend to go? Are we, thoracic surgeons going, or are we being taken? The published procedure numbers—the bigger the better—are the strongest arguments regarding this debate. But can we rely only and exclusively on the procedural volumes? As the calculus illustrates, as the numbers are increasing, the actual individual in need of surgery is disappearing, swallowed up and lost among the mass. The individual patient and the individual surgeon follow the suit. The relevance of a mass observation reduces actual doubts. The importance of haptic information transmitted by the palpating finger of the surgeon has no voice. The tactile signal cannot be replaced by 3D imagery. There is no real progress regarding the orientation of small intraparenchymal lesions, an increasingly relevant issue as the low dose CT screening offers more and more undefined

lesions. Artificial Intelligence may reduce the number of false positive cases (71), however the consequence of Virchow's aphorism: "omnis cellula e cellula" (72) meaning, we still need a cell-based diagnosis is not entirely cancelled... yet. More than half a century has passed since Turnbull, the British surgeon who intuitively laid down one of the cornerstones of every cancer surgery the "do not touch" law (73). Staring at the screen when the lung lobe is paged and paged and paged in search of the lesion and the best access—one cannot resist in wondering if today the Turnbull law is abided by? The same doubt might emerge when the Koch bacilli are pressed to spread around when "minimally invasive" tuberculosis surgery is the name of the game.

Present continuous tense

The surgeon, his/her tool, and the interpretation of published results are the topics deserving a closer look, a sort of special attention with a critical approach.

The case of the surgeon

The patient and his/her surgeon remain the central elements in the outcome of any operation, in spite of the obvious importance of the team of healthcare coworkers and the dense wooded areas, sometimes a literal jungle of technicalities. Here we concentrate on the issue of the surgeon, an undeniably definitive prognostic factor regarding the outcome in different types of surgery (74). Limiting the role of the surgeon to merely cutting is a common preselection bias in rare studies brave enough to value the actor in consideration of the surgical field. Looking at the surgeon more or less exclusively as an operator (high tech assembly line worker) obscures the function in decision making (multidisciplinary team, pre and postoperative care). It is the public image, yet we should know better and ought to present better.

The surgeon is subjected to a learning curve (in which the object is the individual patient, represented here by a single dot (75) where an underestimated factor is hiding, i.e., the generation issue. The thoracic surgeons of the "lost generation" (born between 1920 and 1939) were the first to use surgical staplers as a routine procedure between 1970 and 1990 (17,18). Their surgical career witnessed the case profile shift from tuberculosis (7) (haemoptysis emergencies, thoracoplasties and elective lung resections) to lung cancer. Those chest cutters belonging to the Baby Boomer generation (date of birth from 1940 up through 1959) established their independent practice (consultant level) and were exposed to the first wave of video assisted

techniques commencing roughly from 1990 onwards. Procedures performed on inflated and moving lungs and swinging hilums exposed to all challenges of single lumen orotracheal intubation ruled their training years, while Carlens and White and eventually Robertshaw tubes offered the miracle of the collapsed ipsilateral lung (76). It was the Generation X (born between 1960–1979) whose training and junior consultancy agreed with the fast forward phase of the MITS. The millennial or snowflake generation—tagged as Y [1980–1995] are digital natives, born with a joystick in their hands. Our residents and other junior staff of the thoracic surgical units/departments are the members of the generation Z [1996–2007] and they were raised using smart tools, virtual reality as a natural routine in their daily lives. For some obscure reason these gadgets are generously referred to as intelligent tools, which is a quite sad reflection on what the public considers intelligence.

The generation issue is an acute question with a biological answer regarding the transition as the boomers are now exiting the scene. The focused shift from the former “what” to the new “how” is palpable in the OP theaters and audible in consultations. Both questions are important, however the sequence of the elements making up the sentence is crucial. It is the lung lesion of the patient, and precisely what the surgeon is going to remove using a particular technology not the other way around. VATS pneumonectomy is an easy procedure managing two vessels and the main bronchus, while a bronchial sleeve resection, not to mention the complex plastic procedures is reserved for only for the best of best regarding keyhole surgery. The defiance of the minimally invasive pneumonectomy is uncomfortably strongly opposed by a conversion to open thoracotomy and sleeve resection and replantation. This is exceptionally true in which one faces challenging concrete-like hilum not infrequent in tuberculosis or in neoadjuvant therapy scenario following immunotherapy or chemoradiation. Hooked on VATS as exclusive method of diagnostic lung biopsy exposes the acute respiratory distress syndrome (ARDS) patient unnecessary risks.

Portal surgeons easily cave under the pressure of the rule of cosmesis. MITS is fashionable, VATS/RATS is considered modern; who want to be labelled old school? The pressure stems from different walks of life: referring physicians and the half-informed but strongly opinionated public. Twenty years ago every “well informed and enlightened” patient craved for laser surgery while today’s media-hyped health consumer wants only to be vatsed or

nothing at all. Who is brave enough in struggling if the next door is offering keyhole surgery or even robotic procedure to whatever ailment in question?

There is an educational issue as well. As open thoracotomy is going to be cancelled, falsely “proven” retrograde and even harmful, a new generation of surgeons are growing up who are unfamiliar with the anatomy and techniques of open thoracotomy. We already see the phenomenon with the cholecystectomy or situations in which an appendectomy via laparotomy possesses a real challenge. Tomorrow’s new wave of surgeons are arriving with highly limited contingency or B-plans to solve perihilar technical problems resistant to VATS solutions (77,78) or even anesthetic trouble associated with failed double lumen intubation since they are technically undereducated to convert procedure. We saw (and are politely remained tight-lipped) when for some reason the benefit of single lung insufflation is not offered. The result is a quick: “inoperable case” decision; while it might be only operable under two lungs ventilation. Open procedures are needed in an absolute majority of acute trauma cases and in times (and geographical places) of financial crisis or limitations (79). The philosophy of damage control thoracic surgery war/military surgery (80) is set against minimal invasiveness in which the trauma is maximal in its destruction and the only thing we do not possess is the element of time. Modern surgical handbooks are short on hand-stitched bronchial stumps. There is a real danger in thoracic surgeons who can manage a bronchial resection using a surgical stapler, or not at all. The knowledge of differences in the length of the central stump achievable by use of a stapler opposed by manual sewing, sometimes offering the oncological safety zone, seems to be fading away. Big data are covering the nuances (81).

The end of the paragraph regarding the subject of the MITS procedures calls for the mention the concept of the “technical imperative” (82). This is a sort of pervasive instinct of action orientation by means of non-desired hyperactivity, blindness to alternatives, and a lack of multilayer and multiaspect consideration, if a certain procedure is taught and promoted enough. Sooner or later it will be used with a frequency greater than its reasonable and legitimate indication. The impetus of the autoweight is a great motor power. The learning curve of the individual surgeon consists of dots; every one representing a human being, marking a life not less valuable than the operator (75).

The case of the stapler

No question, surgical staplers were game changers in thoracic surgery highlighted in several stages (83). At the time being endoscopic staplers are sine qua non of VATS and RATS procedures as well.

The surgical stapler bears one very strange feature, assuming one trusts the published data: they nearly never cease to function properly (84,85). Machine failure never happens, at least the publications are very shy regarding this topic, if one compares the experienced technical problem numbers in the empirical observation of the daily routine which is somehow between 1/100–150 procedures. Actual mechanical failure reports depicted in major publication domains are rare as a black swan (86,87). It is not new, however in consideration of the phenomenon of missing reports on stapler malfunction or failure is as old as the surgical stapler itself. While malfunction is an underreported event even in open surgery (88) it may prove fatal where vessel securing is concerned (89-91). A minimally invasive environment is exposed to stapler misfire (92,93) a situation in need of experience in open procedures. To make bad things worse, a decision to convert procedure into open chest surgery (94) is very hard to be taken by a junior consultant undertrained in open field surgical crisis management.

Surgical staplers are an enormous source of profit which makes them report-sensitive where mechanical failures are concerned. The environmental question, masqueraded as the green issue poses yet another cautionary tale, a warning sign of peril in the road ahead. Admittedly the used disposable stapler is biological and plastic waste. No surgery is free from its significant ecological footprint, as the byproducts are but toxic waste in need of specialized care and deposit. While this is an inevitable fact, it does not justify the lack of risk reducing measures. The vast amount of plastic to be discarded is not capped off nor carved into marble. Reloadable staplers are obviously reducing the profit of the producers and resellers. One of the potential responses to the question of reusable surgical staplers is the renaissance of metal staplers. Emergency situations—military surgical application included (86)—are typified by limited storage spaces and limitations in load-bearing strength. It is obviously much more space-friendly, to use reloadable cartridges than when compared with disposable all-in-one staplers, not to speak of makeshift yet still reliable sterilization processes. What is true for the staplers for open thoracic/abdominal procedures, may prove true in a lesser

degree for video assisted interventions, mutatis mutandis.

Procedures

Diseases and their interpretation in the publication domain

The case of pneumothorax

Pneumothorax is one of the more obvious indications regarding VATS procedures, a queen of the non-malignant cases. Definitive surgery—resection of bullae, leaky apical regions, with or without pleurodesis/ectomy via open thoracotomy experiences a recurrence rate less than 1% according to published historical data. Many low volume center during the open surgery era never witnessed a single recurrence. The simplicity of the procedure made it an ideal candidate for VATS from the onset. When the first critical reviews have been published, recurrence rates were less than satisfactory with a recurrence rate hovering at or about 10% in 2006 (95). More than a decade later, the recurrence rate is a little bit higher and no one dares question the exclusive rule of VATS (96). While the honesty of the report is admirable, a loss of critical thinking and a lack of readiness for rewriting new and exclusive norms and canons is reason enough for consternation. VATS for pneumothorax at any cost in any case is the “holy cow” of dogmatic thoracic surgery.

The case of mythology

The garden of mythology and the undisputable advantages of VATS has many flowers and is indeed, a rich bountiful bouquet. At its core, characterizes what to trumpet about and when to remain silent. There is an old public relations (PR) method in which the first thing to find is a proper adversary to prove the advantages of one's product. The standard comparator regarding the VATS approach is an impressively extensive posterolateral or lateral thoracotomy. The three main outcome indicators include pain, in-hospital days and the function-cosmesis complex. Pain is a highly subjective and a manageable factor if proper attention is paid to it. Investigations regarding returning shoulder function are not conclusive. Open thoracotomy incision affects one intercostal bundle while a 3-port VATS implies three different intercostal nerves. With regard to the cosmesis factor comparative photos on open vs VATS scars are, at first glance, seemingly convincing: there is an impressive difference. However, the advantage exists only if a posterolateral thoracotomy is the comparator and muscle sparing approaches (axillary thoracotomy) are rarely or

never mentioned. The Hamletian question of “to spread or not to spread” involves a comparative among apples to oranges. Intercostal spreaders from Finochietto to Burford and further become public enemy number ones regardless to the aim of the operation and the command of safety referencing the procedure.

The myth of return to work forgets the fact, the significant majority of cancer patients are within the retirement age group.

Where days infirmed are counted (always shorter and never mentioned the source of observational bias) minutes of operational times are frequently omitted. The reader is forced to consult other types of papers in which the operational times in minutes is reported. The much-heralded advantage regarding VATS in-hospital days is counterweighted by the time, in which the patient spends on the operational table in the theater (97). In-hospital stays are loosely related to the actual surgical technicality, connected to other non-operative or even extramedical factors and are famously multifactorial, and ultimately bias sensitive.

Bleeding volume comparations are frequently cited, a clinically insignificant factor as transfusion is today no longer the case when referencing standard lung resection. Therefore the significancy tests on millilitres are meaningless yet very impressive.

Discussion

Present

There are three crucial interfering interests to consider in which the absolute benefit of a given treatment modality is concerned. They are strictly hierarchical in the following inflexible order: the patient, his/her doctor and society. The wellbeing of the patient is the superior law (“salus aegroti suprema lex esto”), the performer of the healing act in accordance to the state of art and the healthcare system (society level) covering the bill (“He who pays the bill chooses what music the gypsy will play”—old Hungarian proverb). The technique is in support of the surgeon and not the other way around, and the surgeon does so for the benefit of the patient (98). As far as budget is concerned, state sponsored and/or private insurance officials and hospital management are acting as gate keeping intermediaries and no sensible surgeon can ignore the fact—like it or not.

There is no doubt about it, video assisted thoracic

surgery has been a game changer in chest surgery arriving center stage some three decades ago. Many cases irresectable by old style tying/stitches are safely manageable purely by the use of dependable vascular endostaplers. There is a paradigm change in surgical training, as today’s juniors are exposed to a limitless number of high quality videos and virtual reality training facilities, all willing to generously offer their services. The days of the surgical apprenticeship and manservant style knowledge transfer are fodder for the elephant graveyard. The question posed is, is it a benign ally, a new king open for power sharing, or a tyrant to rule exclusively the domain? Who are the impostors? The answer is defined by the main aim of the operator. The purpose of all surgical activity is maximizing the number of patients alive at five years or whatever number of years following surgery. What must be kept in mind, is evolvment must be interpreted in the context of the art of surgery in its inherent hierarchy, based on rules accumulated from the time of Aeculapius and Hyppocrates in ancient Greece/Hellas and their contemporary masters in medicine in the eastern hemisphere of which must be followed. The resilience, the sovereignty of the surgeon, a physician who is able to treat the patient using the methods of contemporary surgery, a humble artist who rules the operative technique and technologies and never the other way around.

Surgical technique questions (98,99) such as open thoracotomy procedure or VATS/RATS methods should be a matter of pure scientific and clinical consideration definitely not a sort of quasi religious conviction. The struggle for hegemony does not help either. The uniportal *vs.* multiportal approach controversy is a debate on how to enter the room and not on what is to be done once one is inside. In our consumer age of the algophobia long term survival as a primary quality marker is in a danger of being replaced by short term factors like visible scar, days spent in the hospital; an undesirable shift from concrete results to the superficiality of symptoms and reception. Surface against the depth. It looks if thoracic surgery is approaching a certain point, where industrialism takes over the lead, a line not to trespass, a line worth defending.

Future

There is no way in ever returning back to square one, where vessels were tied and lung parenchyma was sewn using hand stitches via incisions extending from spine to sternum.

The future of MITS is bright however not without snares

and trapdoors. The task of the surgical community (100) and those aligned to it, the thoracic surgeons chapter, pledge to protect the interest of their patients while representing the real and best interest of their guild. It will be a very serious mistake to see the (mis)informed public and the industry as an enemy just because they have their own different areas of interest. The public is influenced by the media and the motor of the industry is called profit. What the complex system needs are brakes and checks; offered by the surgical community. A desperate fight against buzz words with primitive reductionism such as “key hole surgery” and professionally misleading ones including “minimally invasive” is obviously hopeless. The media needs simple messages regardless of the professional correctness of the meaning of expressions. The only way forward for the profession is to become more transparent and self-controlled, ensuring the flame regarding classical values continues to burn while focusing upon the dire needs of today’s patient, including society, in general (“Salus populi suprema lex esto”).

All we have to do now: be honest and meaningful in reporting, humble in our analysis and much more aware of tempting biases. It may be too much to ask for. Comparing apples to apples oranges to oranges and wary not to compare incomparables or parading inconsequentialities using ephemeral statistics.

Where the technicalities are concerned, mechanical tissue fusion will be replaced by energies, at least in vessel control. Tensegrity mechanisms, composed of rigid and tensile parts will replace those rigid choplike manipulators. Hybrid electromagnetic, electropneumatic or hydraulic microactuators with an increasing degree of freedom will ensure the access is easier. Independent (non-wire) small robots and cable-free image sources will likely be developed. Intraparenchymal orientation and lesion location requires the same attention as decreasing pressure trauma to the tumor and surroundings parenchyma. However the crucial question regarding the costs remains open, while the real value is measured in survival and quality of life. System resilience must be increased in case of electromechanical failures, communication breakdown, while environmental friendliness cannot be compromised. In a wider context of the long run, the future role of resective surgery in lung cancer seems to be questionable (101).

The tale of the vanishing role of surgery in tuberculosis must be instructive for us now. Similarly, novel anti-cancer treatments modify the need for the fingers of the surgeons much like the stents and transvascular procedures changed

the game for cardiovascular surgeons. What remains unaltered, is the attitude, the ethos of surgery (98,99). We can keep its fire lit but only if we elevate our vision above the horizon of pure technicalities.

How to proceed?

It seems clear, the surgical community must practice a far more critical attitude towards surgical technologies than is currently underway. More research and discussion regarding the numbers of lymph nodes to be removed and/or to be oncologically correct (102) rather than hot debate on the numbers of accessing ports is required. A negatively impressive number of lung cancer surgeries are performed in Europe and in the USA without correct lymphnode staging (3xN1;3xN2) while many are heralding their user friendly VATS/RATS procedures. Readiness to VATS/RATS > open procedure conversion as in the case of pilots are trained in emergency procedures must be promoted. Preferring VATS over open techniques as a general rule is representative unfair pressure and a precipitous example heaped upon our junior staff. Absolute priority of the proven negative bronchial ring/resectional line during surgery is a mantra and one in which we must keep chanting. Educating the younger generation how to read and interpret even doubt in published reports must be a priority. There is no hope expecting predator journals accepting more negative result papers (stapler failures) yet being critical on matters of terminology (differentiating between acute trauma *vs.* sequels; and avoiding superficial generalisations) should become a minimum of standards. Where affordability is concerned, the real investment/cost/dividend means precise data are required. An eye for the not so rich economies and less fortunate countries has its pay day.

A more self reflected surgery cannot ignore the classical moral and professional values centering on the needs of the patient and the capacities of society. Too high a dependency on high tech results in lack of plan B when an unexpected electromechanical failure occurs, malware virus infects our digital platforms or even the potential for an adversary attack.

Conclusions

The role of the devils advocate is over, the picture is framed. What seems obvious is recognizing how, professional platforms apply the scientific checks and guideline brakes otherwise the MedTech industrial forces and other

extramedical interests assumes the upper hand. Technical aspects are motors of clinical progress, yet developing optimal treatment modalities is a far more complex issue. Invasiveness regarding thoracic surgery must be optimized and not minimized; this is not like the question of the suitable length of skirts or trousers. Editors, peer reviewers and scientific networks bear enormous responsibility. Their independence remains a key element. Additionally the interest of the industry must be optimized also in spite of their maximizing instinct. Selling data, turnover and profit are not in the interest of our patients. The consciousness is emblematic of the scientific bodies and their voices: evidence-based forms of communications and open frank discussion highlighting pressure-free decisions of the individual thoracic surgeons ensures an optimal service our patients richly deserve. This is the way to maintain the standards we inherited from our respected and revered thoracic surgeon masters, our forefathers.

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