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CLINICAL ENGINEERING APPLIED TO THE SURGICAL ENVIRONMENT:

SCIDP PROTOCOL AND THE STANDARDIZATION OF VIDEO-ASSISTED SURGERY SYSTEMS

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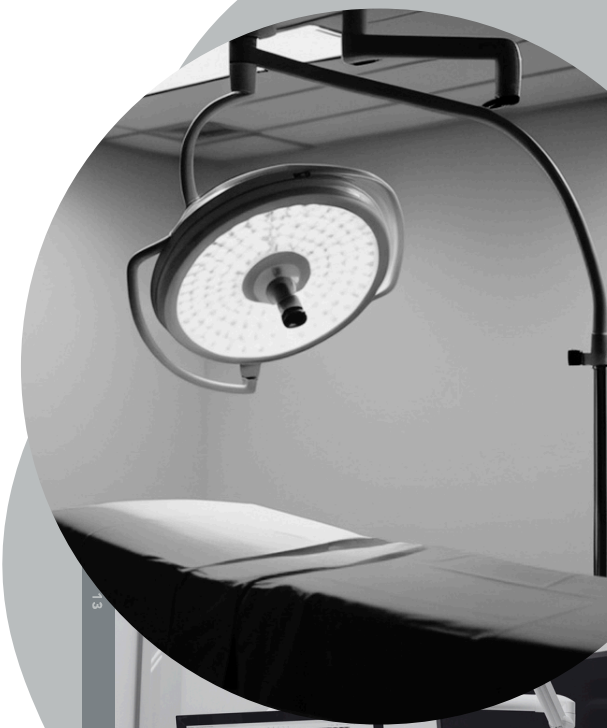

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ABSTRACT

This edition academically systematizes the SCIDP Protocol (Standardized Capture and Image Documentation Protocol) as a technical-operational standardization framework for intraoperative support in video-assisted surgery systems. The work is based on the premise that the contemporary operating room constitutes a highly complex sociotechnical environment, in which patient safety depends not only on clinical skill, but also on the reliability of technological infrastructure, the quality of interprofessional communication, and the traceability of processes. Based on a narrative review of international guidelines, Brazilian regulatory documents, clinical engineering manuals, and peer-reviewed literature on technological failures in minimally invasive surgery, it is shown that the gap between institutional maintenance and real-time technical support remains insufficiently formalized, especially in the Brazilian context. The text proposes that SCIDP be understood as a process technology structured around three pillars: preventive diagnosis, immediate intervention, and multisystem adaptability. In addition to detailing the architecture of video-assisted surgery, the work presents checklist, traceability, training, indicator, pilot-project, and multicenter validation agenda instruments. The quantitative results originally associated with the protocol are retained only as exploratory evidence derived from unpublished operational records and are explicitly distinguished from the consolidated evidence in the literature. It concludes that specialized intraoperative technical support deserves recognition as a component of clinical governance and surgical safety, and that protocols such as SCIDP may contribute to reducing avoidable interruptions, improving documentation, and creating a basis for predictive maintenance and digital surgery.

Keywords: Clinical engineering; Video-assisted surgery; Patient safety; Technical checklist; Intraoperative support; Traceability; Digital surgery.

PREFACE

At a time when the operating room has become one of the most technologically dense environments in health care, it is no longer possible to think of patient safety solely on the basis of clinical action or the individual skill of professionals. Contemporary surgery, especially minimally invasive surgery, depends on a complex network of equipment, integrations, parameters, images, flows, and rapid responses that, when they fail, compromise not only procedural performance but the very reliability of care. It is precisely at this point that this work proves necessary.

Clinical Engineering Applied to the Surgical Environment is not merely a book about equipment, nor merely a reflection on processes. It is a work that occupies a strategic zone still insufficiently formalized in the Brazilian debate: the interface between surgical technology, work organization, and care safety. By systematizing the SCIDP Protocol, Matheus Moreira Soares offers more than a set of operational guidelines. He offers a mature reading of a real, recurrent, and long underestimated problem: the absence of sufficiently structured technical-operational routines to sustain the readiness of video-assisted surgery systems when they are most required.

The merit of this work lies, above all, in transforming practical experience into consistent formulation. The author begins from knowledge constructed in the field, in the concrete rhythm of the operating room, but refuses the trap of disorganized empiricism. Instead, he converts this experience into an object of academic systematization, connecting specialized literature, regulations, international guidelines, and qualified technical observation. In doing so, the book helps fill an important gap: that of recognizing that specialized intraoperative technical support is not accessory, improvised, or merely corrective, but an integral part of clinical governance in highly complex environments.

Throughout the chapters, the reader will perceive that the strength of SCIDP does not lie in promising infallibility. Its value lies in something more solid and more realistic: reducing dangerous variability, anticipating foreseeable failures, structuring safe responses, improving documentation, and creating conditions for institutional learning. In other words, it is a protocol that understands that reliability does not arise from brilliant improvisation, but from intelligent repeatability, well-designed traceability, and disciplined interprofessional communication.

Another aspect that deserves emphasis is the way in which the book restores visibility to work that is frequently invisible. In many services, the fluidity of surgery depends on highly specialized technical competencies, but these are not always formally recognized in hospital organizational charts. By naming this activity, describing it, and inserting it into the field of care quality, this work contributes not only to the literature, but also to the appreciation of a function that silently sustains the stability of the surgical environment.

There is also an important methodological virtue in this text: its prudence. The author does not confuse a promising hypothesis with definitive evidence, nor localized experience with universal truth. By distinguishing exploratory results from consolidated evidence, the book gains credibility and scientific maturity. This stance strengthens the proposal because it presents it as what it indeed is: a robust, technically relevant, and academically promising contribution that deserves to be tested, improved, validated, and institutionalized.

This preface, therefore, presents not only a book. It presents an agenda. An agenda for the professionalization of intraoperative technical support. An agenda for integration among clinical engineering, surgery, quality, and management. An agenda for recognizing that, in the contemporary operating room, technology without process is organized fragility. And, above all, an agenda committed to

the idea that patient safety is also built through the quality of the connections, verifications, records, and technical decisions that precede and accompany the operative act.

May this work be read with the attention that inaugural works deserve: not as an endpoint, but as an initial milestone in a field that needs to grow with method, evidence, and responsibility. If this happens, the book by Matheus Moreira Soares will have fulfilled a rare and valuable function: transforming specialized practice into a reference for thought, and operational necessity into a governance project for the surgery of the present and the future.

Brazil, May 2026.
Matheus Moreira Soares
Organizer

SUMMARY

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INTRODUCTION

Objectives of the Study

General objective: To systematize the SCIDP Protocol as an academic framework for standardizing intraoperative technical support in video-assisted surgery systems. Specific objectives: (a) to map the relevant regulatory and scientific basis; (b) to describe the technical architecture of video-assisted surgery and its failure modes; (c) to structure instruments for checklist, traceability, and training; (d) to propose indicators and an implementation roadmap; and (e) to outline an agenda for scientific validation.

The accelerated incorporation of surgical technologies in recent decades has transformed the operating room into a highly complex sociotechnical environment. High-definition cameras, laparoscopy towers, insufflators, light sources, recording systems, digital integration, and, more recently, robotic platforms have become part of the infrastructure of hospitals of different sizes. This modernization, however, has not been accompanied, at the same pace, by the consolidation of standardized technical routines for verification, calibration, contingency, and traceability of these systems during the operative act. In other words, technological sophistication has increased dependence on reliable technical processes while also exposing organizational weaknesses that remain insufficiently described in the national literature (BRASIL, 2002; DEL SOLAR et al., 2017; TOSCAS et al., 2023).

Internationally, surgical safety became consolidated as a central agenda through initiatives such as the World Health Organization's Safe Surgery Saves Lives program and the publication of the WHO Surgical Safety Checklist, an instrument that helped structure critical checks before anesthesia, before incision, and before the patient leaves the room. In the study that accompanied implementation of the checklist, Haynes et al. demonstrated reductions in complications and mortality in a heterogeneous surgical population, showing that work organization and standardized verification are as relevant as individual technical skill (WHO, 2009; HAYNES et al., 2009).

In Brazil, standardization related to patient safety, processing of health products, and management of the technological equipment base is relatively robust in general terms, but it does not sufficiently detail the intraoperative micromanagement of video-assisted surgery systems. ANVISA RDC No. 36/2013 established actions for patient safety in health services, and the National Policy for Health Technology Management assigned to public authorities and managers the duty to support the implementation, monitoring, and maintenance of incorporated technologies. Even so, an operational void remains between

the normative guideline and real-time technical execution in the operating room, especially when different brands, generations of equipment, and surgical preferences coexist within the same service (ANVISA, 2013; TOSCAS et al., 2023).

It is within this space that the SCIDP Protocol (Standardized Capture and Image Documentation Protocol) is situated, presented here as a technical-operational standardization framework aimed at intraoperative support in video-assisted surgery systems. This material is organized in four directions: first, it adds theoretical and regulatory grounding; second, it repositions SCIDP as an object of academic reflection and not merely as a practical routine; third, it distributes references and sources throughout the text; and, finally, it makes explicit the differences between consolidated evidence in the literature and exploratory results derived from the author's own operational records.

From a methodological standpoint, this book adopts a problem-oriented narrative review, combining normative documents, technical manuals, international guidelines, and peer-reviewed literature on patient safety, clinical engineering, technological failures in surgery, and the use of checklists in minimally invasive procedures. The objective is not to replace future clinical trials or multicenter evaluations, but to build a consistent framework for analysis, implementation, and progressive validation of the protocol. As an interpretive axis, it uses Donabedian's classic structure-process-outcome triad, articulated with concepts of human factors, safety culture, and risk management in high-reliability environments (DONABEDIAN, 1988; REASON, 2000).

The central hypothesis defended is that intraoperative technical support, when treated as a structured, trainable, documentable, and auditable function, contributes to reducing avoidable interruptions, increasing the functional availability of equipment, improving communication among teams, and strengthening patient safety. More than a collection of checklists, SCIDP is presented as a system of operational governance for surgical technology. This distinction is crucial: protocols become sustainable when they are connected to training, indicators, documentation, institutional learning, and

formal mechanisms of accountability (AORN, 2022; ROYAL COLLEGE OF SURGEONS OF ENGLAND, 2025).

TRANSFORMATION OF THE OPERATING ROOM AND GAPS IN TECHNOLOGICAL GOVERNANCE

The spread of minimally invasive surgery has changed the logic of surgical work. Instead of predominant dependence on manual instruments and direct exposure of the field, the operation has come to depend on chains of transmission involving light, image, insufflation, and recording. This means that surgical performance has become inseparable from the technical performance of the system. When the image deteriorates, insufflation fluctuates, or integration between camera and processor fails, the problem is not peripheral; it affects visualization, spatial orientation, operative rhythm, and, at certain moments, the very safety of dissection. The literature on surgery and performance in the operating room shows that organizational factors and technological failures directly interfere with procedural flow, team communication, and the occurrence of avoidable delays (WEERAKKODY et al., 2013; PASQUER et al., 2024).

This context requires a broader interpretation of surgical safety. Error cannot be interpreted only as an individual deviation by the surgeon or the nursing team; it may also emerge from the arrangement of the system, the absence of standardization, deficiencies in maintenance, incompatibility between components, and inadequate communication among professionals with distinct technical languages. Reason, in discussing human error in complex systems, showed that accidents usually result from combinations of active failures and latent conditions. In the operating room, these latent conditions include uncoordinated acquisition of equipment, heterogeneous training, incomplete documentation, absence of functional backups, and lack of escalation protocols in the face of incidents (REASON, 2000).

The World Health Organization treated safe surgery as a global problem precisely because harm prevention requires minimum standardization in environments that differ greatly from one another. The

WHO checklist was not designed to exhaust all technical variables of each specialty, but to create a shared verification ritual that reduces dangerous variability. This principle can be extended to video-assisted surgery technology: the fact that the WHO asks, before the patient leaves the room, whether there were problems with equipment already indicates that technological infrastructure is not a neutral backdrop, but a component of perioperative safety (WHO, 2009; HAYNES et al., 2009).

Observational studies on communication in the operating room reinforce this interpretation. Lingard et al. identified communication failures in approximately 30% of the exchanges observed among team members, and about one third of these failures had visible effects on the process, such as tension, delays, wasted resources, and the need for improvised workarounds. When technology fails in an environment already pressured by time, sterility, and hierarchy, the likelihood of communicational noise increases. Therefore, any serious proposal for intraoperative technical management must also be a proposal for improving interprofessional communication (LINGARD et al., 2004).

In a systematic review, Weerakkody et al. showed that technology and equipment failures account for a relevant share of errors in the operating room. The authors reported a median of 23.5% of failures attributable to equipment/technology among the studies analyzed, with a median of 0.9 equipment problems per procedure. Although these findings do not refer exclusively to laparoscopy, they offer an important conceptual datum: technological failure is not a rare or residual event. It occupies an intermediate zone between hospital maintenance, logistics, teamwork, and clinical outcome, and therefore tends to escape both strictly biomedical discussions and conventional administrative analyses (WEERAKKODY et al., 2013).

Laparoscopy makes this dependence even more explicit. Verdaasdonk et al. observed, as early as 2007, that technical problems with equipment during laparoscopic surgery were frequent enough to justify a systematic approach. In a complementary line, Siddaiah-Subramanya, Nyandowe, and Tiang proposed a troubleshooting method for surgeons, recognizing that sudden loss of vision or pneumoperitoneum at critical moments may put the patient at risk and that many hospitals still depend on

empirical responses from non-specialized personnel. The underlying message of these studies is convergent: laparoscopy is safe when the system is safe; when the system is unstable, the entire procedure becomes more vulnerable (VERDAASDONK et al., 2007; SIDDAIAH-SUBRAMANYA et al., 2017).

At the institutional level, technological transition also pressures maintenance and procurement models. The Ministry of Health's Manual for the Management of Maintenance of Medical-Hospital Equipment already warned, in 2002, of the need for technical documentation, trained personnel, testing and calibration equipment, and objective criteria for deciding between internal and external maintenance. In hospitals that perform a high volume of minimally invasive procedures, these requirements become more sensitive, because equipment unavailability does not generate only a queue or administrative delay; it may mean case cancellation, loss of an operative window, increased anesthetic time, and frustration of the team (BRASIL, 2002).

Recent literature on operating-room organization reinforces that surgical performance depends not only on technical dexterity, but also on factors such as continuity of flow, familiarity among team members, quality of handover, availability of resources, and equipment readiness. Pasquer et al., in a systematic review, synthesize this movement by treating operating-room organization as a determinant of performance. The discussion is particularly useful for SCIDP because it shifts the focus from the question "who fixes it when the equipment fails?" to a more mature question: "how can the system be designed to reduce the probability, duration, and impact of failures?" (PASQUER et al., 2024).

Table 1

Selected evidence on technological failures and operating-room organization

Source	Design	Central finding	Implication for SCIDP
Haynes et al. (2009)	Multicenter study	Surgical checklist associated with reduced complications and mortality	Standardization and structured verification matter for safety
Lingard et al. (2004)	Observational	Communication failures in about 30% of exchanges; some with visible effects on the process	Technical support depends on clear communication and defined escalation
Weerakkody et al. (2013)	Systematic review	Equipment/technology accounts for a relevant share of operating-room errors	Technological failures are not residual; they require governance
Pasquer et al. (2024)	Systematic review	Operating-room organization interferes with surgical performance	The protocol must articulate space, flow, and technical readiness

Source: Prepared by the author.

CLINICAL ENGINEERING, TECHNOLOGY MANAGEMENT, AND REGULATION APPLIED TO SURGICAL PRACTICE

Clinical engineering emerged as a response to the increasing technological density of health services. Its traditional field includes selection, incorporation, maintenance, calibration, user training, performance evaluation, and decommissioning of equipment. In Brazil, the literature records the gradual consolidation of this area as an interface between management, safety, and rational use of resources, although heterogeneity remains among hospitals and regions. National reviews emphasize that clinical engineering has become strategic as the hospital technological equipment base has expanded, but they also point to persistent limitations related to staff shortages, dependence on external contracts, and the difficulty of transforming technical data into useful managerial information (DEL SOLAR et al., 2017; TOSCAS et al., 2023).

The problem is that the classic model of clinical engineering was conceived, to a large extent, for the equipment life cycle outside the critical moment of use. Its privileged instruments are work orders, preventive maintenance, contract management, inspections, inventories, periodic calibrations, and aggregate availability indicators. These mechanisms are indispensable, but they are not sufficient to govern technology during the operative act, when tolerance for delay is minimal and the risk of

improvisation increases. The operating room demands a specific functional perspective of clinical engineering: an intraoperative clinical engineering, oriented toward real time, human factors, contingency protocols, and structured clinical communication (BRASIL, 2002; IEC, 2014).

Brazilian standardization offers relevant foundations for this discussion. ANVISA RDC No. 36/2013 instituted patient safety actions and required health services to develop risk management strategies. RDC No. 15/2012 regulated the processing of health products and consolidated important requirements related to cleaning, disinfection, sterilization, and traceability. In parallel, the National Policy for Health Technology Management reaffirmed that technology incorporation must be accompanied by monitoring and maintenance. None of these regulations, however, details intraoperative routines for technical support to video-assisted surgery towers, which creates a regulatory gray zone: responsibility exists, but concrete operationalization is left to the maturity of each institution (ANVISA, 2012; ANVISA, 2013; TOSCAS et al., 2023).

Internationally, AORN guidelines for minimally invasive surgery, the WHO checklist, and the Royal College of Surgeons' Good Surgical Practice document reinforce three ideas with strong adherence to SCIDP: first, complex systems require standardized preparation; second, documentation and communication are safety components, not mere bureaucracy; third, the surgical team must anticipate foreseeable risks, including those related to equipment and technological integration. Although the recommendations do not describe SCIDP, they provide normative legitimacy for the thesis that intraoperative technical management must be formalized and auditable (AORN, 2022; AORN, 2023; WHO, 2009; ROYAL COLLEGE OF SURGEONS OF ENGLAND, 2025).

IEC 62353, in turn, defines the scope of recurrent tests and tests after repair in electromedical equipment. It is an important reference for electrical and functional safety in health-care use, but again, it does not replace clinical-operational pre-use and intraoperative response protocols. In practical terms, IEC helps ensure that the equipment is safe from an electrotechnical standpoint; SCIDP seeks to ensure

that, in addition to being safe, it is configured, integrated, available, traceable, and ready for the specific context of the procedure and surgeon (IEC, 2014).

The usefulness of this distinction can be perceived when analyzing hospitals with multiple platforms, fragmented purchases, and unequal technological renewal. A properly maintained insufflator may still be inadequate for a given case if the set of hoses, trocars, filters, and configurations has not been validated for that operation. Likewise, an electrically safe camera may produce an unsatisfactory image if coupled to an incompatible optic, if the light source is degraded, or if white balance is ignored. The problem, therefore, does not lie only in the individual state of each item, but in the performance of the integrated system in real use.

It is at this point that clinical engineering needs to dialogue more intensely with the theory of quality in health care. Donabedian's structure-process-outcome triad helps demonstrate that the technical quality of intraoperative support depends on adequate structure (technological equipment base, backup parts, documentation, training), standardized processes (escalation, traceability, auditing), and outcomes (reduction of interruptions, resolution time, functional availability, team satisfaction). SCIDP is conceived in this work as an instrument for connecting these three levels (DONABEDIAN, 1988).

Finally, Brazilian literature on health equipment management suggests that there is still a deficit of post-acquisition plans and long-term sustainability. Toscas et al., when discussing the management of pulmonary ventilators in SUS, emphasized that large-scale purchasing does not automatically translate into robust management, especially when maintenance and monitoring strategies after incorporation are lacking. The analogy with video-assisted surgery is direct: investing in technology without investing in operational governance increases system vulnerability. SCIDP can therefore be read as a micro-operational response to a macro problem of technology management (TOSCAS et al., 2023).

Table 2

Regulatory and normative framework relevant to intraoperative technical support

Document	Main scope	Contribution to the work	Remaining gap
RDC 15/2012 – ANVISA	Processing of health products	Traceability and good processing practices	Does not detail technical-operational preparation of the tower
RDC 36/2013 – ANVISA	Patient safety	Risk management and safety culture	Does not describe specific routines for video-assisted surgery
IEC 62353:2014	Recurrent and post-repair testing	Electrical and functional safety	Does not cover contextual intraoperative configuration
WHO Surgical Safety Checklist	Safe surgery	Shared verification and communication	Does not explore multibrand specificities of the tower
AORN MIS Guideline	Minimally invasive surgery	Safe environment, competencies, and policies	Requires local operational translation
Good Surgical Practice	Good surgical practice	Documentation, team, and responsibility	Does not define a technical troubleshooting model

Source: Prepared by the author.

ARCHITECTURE OF VIDEO-ASSISTED SURGERY AND FAILURE MODES IN INTEGRATED SYSTEMS

The laparoscopic tower should not be understood as a casual set of juxtaposed equipment, but as an integrated sociotechnical system. Its core usually includes an image processor, camera head, optic, light source, cables, monitor, insufflator, recording system, and integration accessories. In many services, irrigation pumps, energy managers, fluorescence platforms, 3D modules, and interfaces for electronic medical records or network recording are added. Each component has its own vulnerabilities, but the most frequent risk does not arise from the isolated component; it arises from interdependencies and from the way the team prepares and uses the set (SIDDAIAH-SUBRAMANYA; NYANDOWE; TIANG, 2017; PARACCHINI et al., 2021).

In practice, image quality is the combined result of the optic, focus, lens cleanliness, light source, integrity of the fiber-optic cable, processor calibration, monitor resolution, white balance, saturation, sharpness, and even the ergonomics of tower positioning. When the surgeon reports a “poor image,” the cause may reside at any point in this chain. For this reason, simplistic approaches based only on turning

on and testing tend to fail: they confirm that the equipment powers on, but they do not guarantee that it is clinically ready for the operation to be performed.

Insufflation deserves separate attention. In abdominal laparoscopic procedures, the stability of the pneumoperitoneum is the condition of possibility for the working space. Losses through defective valves, loose connections, inadequate filters, improperly configured pressure, or incompatible trocars may degrade surgical progression, increase operative time, and induce hurried technical decisions. This also applies to flow oscillations and misinterpreted alarms. In environments with diversity of supplies and brands, this logistical dimension is often underestimated, although it is central to system performance.

Observational studies provide valuable clues regarding the pattern of these failures. Paracchini et al. followed 171 laparoscopies and found that 66 of them, or 38.6%, were complicated by equipment failures. The authors reported that 45% of the causes were related to the instrument itself and 43% to the incorrect combination of system elements, a finding particularly relevant for hospitals that operate multibrand configurations. Along similar lines, Verdaasdonk and collaborators had already shown that an important share of problems arises because the equipment is not correctly positioned, available, or prepared for immediate use (PARACCHINI et al., 2021; VERDAASDONK; STASSEN; DANKELMAN, 2007).

This evidence suggests that a useful taxonomy of failures in video-assisted surgery must go beyond the distinction between “broken” and “not broken.” In this work, it is proposed that they be classified into five classes: availability failures, when the correct item is not present or accessible; integration failures, when components exist but do not operate harmoniously; configuration failures, when inadequate parameters compromise performance; physical integrity failures, when there is wear, damage, or contamination; and traceability failures, when critical information regarding use, maintenance, and service life is not available. This taxonomy makes it possible to design more specific interventions and more useful management indicators.

There is also an ergonomic dimension. The positioning of the tower, monitor, cables, and connections interferes with team circulation, visibility of the field, and the probability of accidental disconnections. In a room already occupied by instrument tables, anesthesia, surgical C-arm, suction devices, and energy systems, spatial organization can reduce or amplify risks. Safe-surgery guidelines and studies on operating-room organization insist on environmental preparation and spatial standardization precisely because the physical environment conditions the fluidity of clinical work (WHO, 2009; PASQUER et al., 2024).

Another decisive point is the relationship between technological complexity and human variability. The same equipment may perform satisfactorily with an accustomed team and poorly with a team that is less familiar with it. This does not diminish the importance of technology; on the contrary, it shows that the system must be designed to be resilient across different levels of familiarity, including through checklists, training, and prior configuration by user profile. The literature on human factors in surgery suggests that standardization does not eliminate autonomy; it reduces the space for unsafe improvisation and frees cognitive energy for clinical decision-making (REASON, 2000; LINGARD et al., 2004).

In summary, the architecture of video-assisted surgery is both material and organizational. It is not enough to know the equipment; it is necessary to know the interfaces among them, the weak points in the workflow, and the way small failures propagate during the procedure. This systemic perception prepares the ground for presenting SCIDP as a protocol oriented by risk, integration, traceability, and technical readiness. More than responding to incidents, the protocol seeks to redesign the relationship between technology and surgical operation.

Table 3

Critical components of the laparoscopic tower and frequent failure modes

Component	Main function	Recurrent failures	Typical operational impact
Camera head	Image capture	Signal loss, intermittence, poor contact	Abrupt loss of visualization
Optic	Image transmission	Fogging, damage, dirt, incompatibility	Blurred or distorted image
Light source / optical cable	Field illumination	Loss of intensity, wear, disconnection	Low brightness and visual fatigue
Insufflator	Maintenance of pneumoperitoneum	Alarm, pressure oscillation, inadequate connections	Loss of working space
Monitor	Image display	Input failure, inadequate resolution, blackout	Ergonomic and visual impairment
Recording/documentation	Procedure record	Storage failure, incorrect identification	Loss of traceability and data

Source: Prepared by the author.

THE SCIDP PROTOCOL AS A TECHNICAL-OPERATIONAL STANDARDIZATION FRAMEWORK

The SCIDP Protocol is presented in this edition as a technical-operational standardization framework aimed at the readiness of video-assisted surgery systems. Its conceptual core begins from a simple premise: in highly complex environments, reliability depends less on technical heroism and more on repeatable, auditable processes that can be adjusted to context. The protocol does not intend to replace institutional clinical engineering, perioperative nursing, or the surgeon's autonomy. Its purpose is to fill the gap among these spheres by organizing a specific layer of intraoperative technical support based on prevention, rapid response, and continuous documentary learning.

In the present formulation, the acronym SCIDP stands for Standardized Capture and Image Documentation Protocol, but its operational interpretation is broadened. The term capture should be read not only as image capture, but as standardized capture of the system's functional state; image refers both to the surgical image and to integrated visualization of tower performance; documentation, in turn, indicates the centrality of traceability at all stages. This hermeneutic expansion is important for bringing the original name closer to the effective scope of the protocol, which goes beyond documentation and reaches the technical governance of the procedure.

Three pillars support SCIDP. The first is preventive diagnosis. It involves physical inspection, integrity verification, compatibility validation, functional testing contextualized by specialty, and personalized configuration by surgeon when applicable. The second pillar is priority-oriented immediate intervention. In the face of intraoperative failure, the protocol establishes a sequence of verification and escalation that prioritizes safety, speed, and the lowest possible impact on surgical flow. The third pillar is multisystem adaptability, that is, the capacity to apply the same basic logic to different platforms and specialties, with specific modules for laparoscopy, arthroscopy, endoscopy, and robotic surgery in hybrid environments.

Preventive diagnosis differentiates SCIDP from merely instrumental routines. Instead of asking only whether the equipment turns on, the protocol asks whether the set is operationally fit for that case, in that room, with that team, and according to the parameterized preferences of the responsible surgeon. This reasoning is close to the evidence on laparoscopic checklists. Romain et al. demonstrated that a preoperative checklist specific to laparoscopic appendectomies and cholecystectomies was associated with a reduction in the risk of incidents and a decrease in time lost because of these events. SCIDP absorbs this learning but expands it to the systemic level of the tower and its traceability (ROMAIN et al., 2012).

Immediate intervention, in turn, begins from the recognition that failures occur even in well-managed environments. The protocol's contribution is not to promise infallibility, but to reduce diagnostic time, avoid random responses, and create explicit escalation criteria. In situations of image loss, for example, the sequence may include checking connections, the light source, video input selection, integrity of the camera head, optic replacement, and activation of backup. In situations of loss of pneumoperitoneum, the logic shifts to connections, valves, filters, sealing, pressure, and flow. The strength of the method does not lie in a single universal solution, but in organizing the order of questions in a consistent and trainable manner (SIDDAIAH-SUBRAMANYA; NYANDOWE; TIANG, 2017).

Multisystem adaptability is indispensable because hospital reality is rarely homogeneous. Medium-sized services frequently operate with combinations of brands, monitors from different generations, optics with asymmetrical wear, light sources replaced at different times, and supplies purchased through bidding processes or separate contracts. Excessively rigid protocols fail in these contexts. For this reason, SCIDP combines an invariable core—objectives, prevention logic, escalation levels, documentation, and indicators—with variable modules defined by platform, specialty, and the local technological equipment base.

From an academic standpoint, SCIDP can be interpreted as a process technology. It is not merely a documentary artifact, but an arrangement of tacit and explicit knowledge that reorganizes work. This approach brings the protocol closer to quality-improvement interventions that operate on behavior, coordination, and predictability. The systematic review by Boghdady and Tang on checklists in laparoscopic cholecystectomy reinforces that task and verification standardization may improve surgical performance by reducing operator errors. SCIDP dialogues with this same horizon, but shifts the focus from the surgical gesture to the readiness of the technological ecosystem (BOGHDADY; TANG, 2022).

Another conceptual contribution of the protocol is to make visible a professional function still poorly described in the Brazilian hospital organizational chart: specialized intraoperative technical support. The formulation proposed here maintains this thesis and radicalizes it: this is an agent of operational reliability, whose practice combines technical competence, reading of the clinical environment, interprofessional communication, rapid diagnosis, and documentary discipline. Without functional recognition of this activity, the protocol risks becoming a document without a legitimate executor.

Table 4

Pillars of SCIDP and their operational developments

Pillar	Guiding question	Main routines	Documentary products
Preventive diagnosis	Is the system ready for this specific case?	Inspection, compatibility, calibration, backup, surgeon profile	Preoperative checklist
Immediate intervention	How can the problem be resolved with the lowest risk and least delay?	Troubleshooting by failure families and escalation by levels	Technical occurrence record
Multisystem adaptability	How can a common logic be maintained across different platforms?	Modules by specialty and multibrand setting	Technical matrix by platform
Traceability	How can learning from use over time be achieved?	History of use, maintenance, and failures	Service-life form and dashboard

Source: Prepared by the author.

Table 5

Example of technical parameters by specialty for tower preparation

Specialty	Optic	Angle	Critical checking points	SCIDP observation
Cholecystectomy	10 mm	30°	Stable image, light, pneumoperitoneum, backup optic	High sensitivity to initial fogging
Gynecology	5-10 mm	0°/30°	Image configuration and monitor ergonomics	Record surgeon profile when applicable
Colorectal	10-12 mm	30°	Light constancy and redundancy for prolonged procedure	Monitor component fatigue
Thoracic	10 mm	30°	Spatial integration of the room and shared visualization	Prepare layout before patient entry
Arthroscopy	4 mm	30°	Pump/flow, optic, and visibility in liquid medium	Use specific distension module

Source: Prepared by the author.

CHECKLIST, TRACEABILITY, AND TECHNICAL DOCUMENTATION AS THE CORE OF THE PROTOCOL

Documentation is frequently treated as a secondary activity in the operating room, something to be completed at the end if there is time. This culture needs to be revised when the object in question is technological reliability. Without standardized recording, failures recur as isolated events; with recording, they become a historical series that can be analyzed, prevented, and used for managerial decision-making. SCIDP assumes traceability as part of technical performance itself, and not as an administrative addition. This choice is consistent with the international patient safety movement, which emphasizes organizational

learning, reporting, and systematic review of incidents (WHO, 2009; ROYAL COLLEGE OF SURGEONS OF ENGLAND, 2025).

The first documentary instrument of the protocol is the technical preoperative checklist. Unlike the universal surgical checklist, it is specific to the tower and its accessories. It must record identification of the procedure, surgeon, room, selected equipment, physical integrity check, cable and connector compatibility, image test, focus, white balance, light-source test, verification of insufflator parameters, presence of critical backups, and relevant observations. When the institution has an interoperable electronic medical record or clinical engineering system, the ideal is for this checklist to be digital; when there is no infrastructure, a structured physical form remains preferable to the complete absence of documentation.

The second instrument is the intraoperative technical occurrence record. Its objective is not to punish, but to produce operational memory. It should include approximate time of the event, phase of the procedure, observed symptom, diagnostic hypothesis, action performed, resolution time, need for surgical pause, equipment replaced, and immediate outcome. This structure makes it possible to calculate indicators such as mean resolution time, recurrence by component, failures per 100 procedures, and distribution by type of cause. In addition, it facilitates root-cause analysis and the preparation of action plans. From a Donabedian perspective, the record articulates process and outcome, transforming the incident into useful data for improvement (DONABEDIAN, 1988).

The third instrument is the component traceability and service-life form. Fiber-optic cables, optics, camera heads, monitors, light sources, and connectors are subject to cumulative wear that is not always perceptible in a single inspection. Systematic recording of use, maintenance, repair, and replacement helps move beyond the reactive logic based only on “it still works.” The Ministry of Health manual on maintenance management already emphasized the importance of technical documentation and the existence of resources for testing and calibration. SCIDP internalizes this logic within the surgical flow,

making traceability applicable to the microcycle of use and not only to the institutional macroprocess of maintenance (BRASIL, 2002).

There is also a legal and ethical dimension to documentation. In a possible investigation of an adverse event, the existence of clear records on system preparation, incidents, and corrective measures allows one to distinguish equipment failure, process failure, communication failure, and improper use. This protects the patient, the team, and the institution itself, in addition to reducing decisional opacity. Good Surgical Practice reinforces that adequate documentation is a component of good practice and professional accountability. In the case of video-assisted surgery, this documentation must include the technical layer, often invisible in traditional surgical records (ROYAL COLLEGE OF SURGEONS OF ENGLAND, 2025).

From an operational standpoint, a good documentary system must be lean. Excessively long forms generate undercompletion; forms that are too short prevent subsequent analysis. The design recommended by SCIDP prioritizes objective fields, checklists, standardized cause options, and residual space for open observations. Whenever possible, closed classification is used to facilitate tabulation. This balance between standardization and contextualization is essential for the sustainability of the protocol in high-volume services.

The literature on checklists in laparoscopy provides indirect support for this proposal. The benefit observed by Romain et al. and the synthesis produced by Boghdady and Tang do not result merely from the existence of a list, but from the list's structuring of attention, anticipation of incidents, and promotion of team coordination. SCIDP technical documentation operates in the same direction: it aligns expectations, makes the invisible observable, and reduces the space for improvisation. In simple terms, what is not recorded tends not to be learned institutionally (ROMAIN et al., 2012; BOGHDADY; TANG, 2022).

Finally, documentation opens the way for auditing and feedback. By reviewing occurrence records monthly, the institution can identify which rooms concentrate more failures, which multibrand

combinations present greater incompatibility, which professionals require training reinforcement, and which components have reached a critical wear threshold. Without this documentary intelligence, technology management remains blind to patterns that silently repeat themselves. With it, the protocol ceases to be merely a checking ritual and becomes a system of continuous learning.

Table 6

Minimum documentary instruments of SCIDP

Instrument	Purpose	Essential fields	Review periodicity
Technical preoperative checklist	Verify system readiness	Case identification, integrity, functionality, backup, observations	At each procedure
Technical occurrence record	Document intraoperative event	Symptom, probable cause, action, resolution time, outcome	At each incident
Traceability form	Monitor component service life	Identification, use, repairs, incidents, disposal	Continuous update
Management dashboard	Monitor indicators and trends	Coverage, failures, time, readiness, corrective actions	Monthly or quarterly

Source: Prepared by the author.

TECHNICAL PARAMETERS BY SPECIALTY, INTERVENTION WINDOWS, AND TROUBLESHOOTING

Although the core of SCIDP is cross-cutting, video-assisted surgery is not homogeneous across specialties. Laparoscopic cholecystectomy, hysterectomy, colorectal surgery, thoracoscopy, arthroscopy, and interventional endoscopy share certain principles, but differ in working pressure, lighting requirements, optical angulation, need for recording, continuous-use time, and sensitivity to transient image losses. A mature protocol must recognize these differences without fragmenting into dozens of mutually incompatible routines. The proposed solution is to work with baseline parameters and specialty-specific modules.

In abdominal videolaparoscopic surgery, pneumoperitoneum stability, image sharpness, and availability of backup optics are central variables. Long procedures and fine dissections require light constancy and careful management of fogging, while inflammatory or oncologic cases may require special attention to the availability of energy and recording. In gynecology, standardization of positioning, optic, and the relationship between camera and working field assumes additional importance, given the frequency of rapid changes in depth and manipulation. In colorectal surgery, the longer duration and the need for stable magnification make control of component fatigue and image redundancy particularly relevant.

In thoracoscopy and hybrid environments, the protocol must consider spatial restrictions, coexistence with other imaging systems, and possible monitoring adaptations. In arthroscopy, the logic changes substantially: visualization depends on fluid management, the relationship between the optic and the distension medium, and the integrity of specific pumps. In therapeutic endoscopy, in turn, integration among image processing, disposable accessories, recording, and, in some cases, fluoroscopy requires attention to synchronization between platforms. The value of SCIDP lies in offering a common language for these differences, preventing each specialty from operating with entirely isolated solutions.

Configuration by surgeon profile deserves emphasis. Although standardization seeks to reduce dangerous variability, it need not ignore the legitimate preferences of the operator, especially in image parameters, monitor arrangement, and minor system adjustments. The protocol recommends

distinguishing what is a safety parameter—non-negotiable—from what is a documented preference parameter—adjustable and predictable. This distinction reduces friction at case opening, improves team satisfaction, and prevents improvised reconfigurations during the procedure. At the same time, it preserves the traceability of changes made.

In terms of troubleshooting, it is advisable to work with families of problems. The first family involves total image loss; the second, progressive image degradation; the third, recording and storage failures; the fourth, insufflation or distension failures; the fifth, incompatibilities between accessories and platform. For each family, SCIDP proposes a fixed sequence of questions: Is the symptom continuous or intermittent? Does it affect one component or the entire chain? Is redundancy ready? Is correction possible without pause? What is the point of lowest cognitive cost for intervention? These questions organize decision-making and reduce diagnostic dispersion.

The notion of intervention windows is also relevant. In some stages of the procedure, a brief pause to replace the optic or reconfigure video input is tolerable; in others, such as critical vascular dissections, the intervention must prioritize the least possible intrusion, including immediate activation of previously prepared backup. This means that the protocol is not only technical; it depends on reading the surgical moment. Such reading requires proximity to the team, familiarity with the procedure, and sensitivity to the criticality of each stage.

Finally, specialty-specific parameters also serve as a basis for comparative analysis. If a given unit presents a higher incidence of image loss in colorectal surgery than in gynecology, or more distension failures in arthroscopy than in laparoscopy, the institution begins to see where its real vulnerabilities lie. The protocol ceases to be an abstract model and begins to generate situational intelligence. It is in this transition from standardization to contextual analysis that one of SCIDP’s greatest virtues lies.

COMPETENCIES, TRAINING, AND INTERPROFESSIONAL INTEGRATION

No protocol is sustained solely by its technical design; it depends on the competencies of those who execute it and on the way it articulates with the team. In the case of SCIDP, this is even more evident because the executor acts in a boundary space between technology, surgery, nursing, and management. The required training combines mastery of hardware and software, understanding of surgical flow, notions of asepsis, communication in a sterile environment, temporal prioritization, and structured recording of occurrences. This is a hybrid profile, rarely fully contemplated by traditional forms of training.

Competencies can be organized into four axes. The first is technical-systemic: tower architecture, connectivity, calibration, multibrand integration, imaging principles, and identification of failure modes. The second is clinical-operational: understanding of the procedure, the critical stages of surgery, and the potential impact of each failure on the patient and on operative time. The third is communicational: the ability to inform the team with precision, brevity, and respect for clinical hierarchy, without losing diagnostic autonomy. The fourth is documentary and analytical: completion of records, interpretation of indicators, and participation in improvement cycles. The absence of any of these axes makes the activity incomplete.

AORN, when addressing minimally invasive surgery, emphasizes environmental preparation, safe use of equipment, team competencies, and review of policies and procedures. Although the guideline is primarily directed to perioperative nursing, its logic is fully compatible with the training proposed here. The WHO also demonstrated that checklists work better when accompanied by training, local leadership, adaptation to context, and continuous feedback. In other words, protocols depend on trained people and on a favorable organizational culture; they do not prosper by simple documentary imposition (AORN, 2022; WHO, 2009).

Communication is particularly sensitive. Lingard et al. showed that communication failures in the operating room have direct effects on delays, tension, and the need for improvised solutions. In

intraoperative technical support, communication must be both economical and clear. It is not recommended to overload the team with unnecessary electronic details; it is recommended to translate the problem into the language of operational impact. Saying that “the camera head has lost signal and I am moving to the backup unit, with no need to interrupt dissection” is different from listing technical diagnoses disconnected from the immediate clinical need (LINGARD et al., 2004).

From a pedagogical standpoint, SCIDP training should combine theory, simulation, and supervised practice. Theory provides foundations; simulation makes it possible to rehearse image loss, insufflation failure, cable disconnection, component replacement, and communication escalation without exposing patients; supervised practice consolidates real-time judgment. This arrangement is akin to training models in safety and human factors used in other high-risk areas. It also dialogues with the literature on laparoscopic troubleshooting, which recommends a systematic and repeatable approach so that the response to failure is less dependent on improvisation (SIDDAIAH-SUBRAMANYA; NYANDOWE; TIANG, 2017).

Another important point is the institutional definition of roles. The team needs to know, before the problem occurs, who checks the tower, who authorizes equipment replacement, who activates backup, who decides on a prolonged technical pause, and who records the occurrence. Protocols fail when there is ambiguity of authority. SCIDP therefore proposes escalation levels:

- level 1, autonomous resolution by technical support within a short and safe window;
- level 2, communication to the surgeon and coordination with nursing/anesthesia;
- level 3, joint deliberation on a change of strategy or technological conversion.

This gradation preserves the surgeon’s clinical authority without nullifying the technical responsibility of the protocol executor.

Safety culture is the background of the entire implementation. If the institution punishes reporting, treats incidents as individual moral failure, or tolerates improvisation as a daily virtue, the protocol will tend to be bypassed. If, on the contrary, it values evidence, learning, and process review, SCIDP becomes

a mechanism of organizational maturity. Reason reminds us that safe systems are not those that never err, but those that make error detectable, manageable, and teachable. The standardization proposed here should be read precisely in this key (REASON, 2000).

Finally, training must be longitudinal. With each incorporation of a new tower, new software, new energy platform, or new integration with the medical record, the intraoperative support curriculum must be updated. In hospitals with staff turnover, the existence of teaching material, competency checklists, and a training pathway is as important as the presence of an experienced professional. Mature protocols survive personnel changes because knowledge ceases to be exclusively tacit and becomes institutionally organized.

Table 7

Competency matrix for protocol execution

Axis	Expected competencies	Forms of assessment
Technical-systemic	Tower architecture, compatibility, calibration, backup, troubleshooting	Theoretical test, simulation, field observation
Clinical-operational	Reading of the surgical moment and criticality of the procedure	Case discussion and practical supervision
Communicational	Clear escalation, objective language, coordination with team	Interprofessional simulation and structured feedback
Documentary-analytical	Consistent recording, indicator reading, auditing	Review of technical record and analysis exercises
Ethical-legal	Limits of action, data protection, and traceability	Normative module and internal certification

Source: Prepared by the author.

INSTITUTIONAL IMPLEMENTATION, INDICATORS, AND PERFORMANCE EVALUATION

Implementing SCIDP requires recognizing that each hospital starts from a different baseline. Large university services have multiple rooms, high case variability, and more complex supply chains; medium-sized hospitals deal with multibrand heterogeneity and smaller teams; specialized clinics have leaner processes, but less technical redundancy. For this reason, implementation should begin with institutional diagnosis. This diagnosis includes equipment inventory, mapping of current flows, identification of critical points, analysis of previous incidents, availability of backups, training profile of teams, and documentary review of maintenance.

The second phase consists of protocol customization. The SCIDP core remains stable, but checklists, flows, and parameters must reflect the local technological equipment base. A service focused on cholecystectomy, gynecology, and urology will have criticalities distinct from a center with thoracic surgery, interventional endoscopy, and hybrid procedures. Adaptation is not a license for distortion; it is a condition for adherence. International guidelines for implementation of the surgical checklist emphasize precisely the need for local adaptation without loss of the safety function (WHO, 2009).

The third phase is supervised rollout. During this period, all target procedures begin to be followed using the protocol, but records are reviewed weekly to detect omissions, fields of limited usefulness, practical difficulties, and needs for additional training. This phase is essential because it reveals the actual behavior of the protocol in the field. Many solutions that seem elegant on paper prove infeasible in an intense routine; others, initially seen as simple, show great value. Mature implementation depends on this initial learning.

SCIDP evaluation should combine structure, process, and outcome indicators. Among structure indicators, the proportion of towers with functional backup, the percentage of components with updated traceability forms, and training coverage stand out. Process indicators include adherence to the preoperative checklist, completeness of the occurrence record, and time between detection and first intervention. Outcome indicators should include technical failures per 100 procedures, mean resolution time, technical pauses longer than five minutes, cancellations due to equipment failure, and functional availability of systems. This architecture dialogues directly with Donabedian and allows comparison among institutions at different maturity stages (DONABEDIAN, 1988).

Economic literature shows that surgical complications and inefficiencies have a significant financial impact. Healy et al. demonstrated that surgical complications are associated with substantial increases in hospital and payer costs. Although SCIDP does not have the reduction of clinical complications as its primary outcome, it acts on intermediate factors related to interruptions, delays, and organizational failures. In terms of economic evaluation, the most prudent calculation is to estimate

avoided cost through reduction of lost time and cancellations, without automatically promising reduction of clinical events. This methodological caution is necessary to preserve academic rigor (HEALY et al., 2016).

In this edition, the quantitative results originally presented in the author's base manuscript are retained only as exploratory evidence and properly identified as unpublished operational data. According to that material, local implementations of the methodology would have been associated with reductions in technical failures, decreases in mean resolution time, and increases in equipment availability. These results are plausible and consistent with the literature on checklists and standardization, but they still require formal validation through a multicenter study, with transparent methodological design, inclusion criteria, adequate comparators, and reproducible statistical analysis (BOGHDADY; TANG, 2022; ROMAIN et al., 2012).

This methodological honesty does not weaken the protocol; on the contrary, it strengthens it. One of the recurrent problems in innovative proposals is the temptation to present any local improvement as definitive proof. In applied science, it is more solid to recognize the stage of evidence: there are robust normative foundations, consistent technical rationality, supporting literature on failures and checklists, and favorable preliminary indications from the protocol itself. The natural next step is a prospective study with multiple centers, standardized indicators, and peer-reviewed publication.

Even before such validation, there is institutional value in pilot implementation. Pilot projects make it possible to verify adherence, measure feasibility, train teams, and adapt forms. In services that do not yet have a mature documentary culture, the pilot can focus on only one specialty and a reduced set of indicators. In more structured hospitals, the pilot can be born interoperable with clinical engineering and quality systems. This flexibility of entry is decisive for scalability.

Table 8

Suggested indicators for SCIDP evaluation

Dimension	Indicator	Synthetic formula	Managerial reading
Coverage	Checklist adherence	No. complete checklists / no. eligible cases	Measures incorporation of the protocol
Reliability	Technical failures per 100 cases	No. failures / no. cases × 100	Allows temporal comparison
Time	Mean resolution time	Sum of times / no. incidents	Expresses operational resilience
Readiness	Functional availability	Available time / total time	Guides maintenance and backup
Impact	Pauses > 5 min	No. long pauses / no. cases	Captures events with greater repercussion
Learning	Corrective actions implemented	No. actions executed in the period	Shows closure of the improvement cycle

Source: Prepared by the author.

Table 9

Example of prudent interpretation of pilot-project results

Observed situation	Possible interpretation	Recommended action
Decrease in reported failures + decrease in documentation completeness	Risk of underreporting	Reinforce adherence and auditing
Stable failures + shorter resolution time	Gain in operational resilience	Maintain training and review backups
Initial increase in reported failures + high completeness	Greater visibility of the problem, not necessarily real worsening	Read trend with caution
High availability + incidents concentrated in few components	Focal traceability/service-life problem	Review preventive replacement

Source: Prepared by the author.

DISCUSSION, LIMITATIONS, AND AGENDA FOR SCIENTIFIC DEVELOPMENT

The main theoretical contribution of SCIDP is to reposition surgical technology within the field of clinical governance. Instead of treating it as peripheral support or a mere maintenance problem, the protocol interprets it as part of the care process. This change has conceptual and practical implications. Conceptually, it broadens the idea of patient safety to include the reliability of the technical ecosystem in real use. In practice, it legitimizes investment in training, documentation, and specialized functions that are often invisible in hospital organizational charts.

The protocol also contributes to bringing together three traditions that frequently proceed in parallel: clinical engineering, care quality, and minimally invasive surgery. The first offers a basis for managing the equipment life cycle; the second provides language for indicators, safety, and continuous

improvement; the third explains, in daily practice, the operation's dependence on image and systemic integration. The merit of SCIDP lies in creating a bridge among these traditions without reducing one to another. This bridge is particularly relevant in countries and regions where technological expansion has been faster than the maturation of organizational processes.

There are, however, clear limitations. This book does not present a controlled trial, does not directly compare hospitals with and without the protocol under an experimental design, and does not offer an already published multicenter analysis of SCIDP. In addition, part of the normative materials used establishes general principles, not specific prescriptions for video-assisted surgery towers. For this reason, the text should be read as a work of theoretical-practical systematization and expanded methodological proposal, not as a definitive national guideline. This distinction is essential to avoid undue extrapolations.

Another limitation lies in the heterogeneity of services themselves. Equipment varies by manufacturer, generation, software interface, and contractual arrangements. Public and private services differ in parts replacement, purchasing autonomy, contract availability, and training capacity. Thus, SCIDP must operate as an adaptable framework and not as a fixed universal list. The future academic challenge is to demonstrate which elements of the protocol core are invariant and which modules can be customized without loss of effectiveness.

The research agenda derived from this work is broad. First, a study with prior definition of indicators and historical or group comparison is recommended. Second, validation of documentary instruments—the technical checklist, occurrence record, and traceability form—is suggested in terms of clarity, completeness, and reproducibility. Third, it is worthwhile to investigate the effect of the protocol on indirect outcomes, such as the team's perception of cognitive load, safety climate, surgeon satisfaction, and nonproductive room time. Fourth, there is room for integration of SCIDP with analytical intelligence, predictive maintenance, and automated electronic recording.

The emergence of digital surgery and connected platforms makes this agenda even more urgent. The contemporary trend is toward expanded integration among video, recording, analytics, telementoring,

and artificial intelligence. The more connected the operating room becomes, the greater the need for protocols that ensure operational reliability and the quality of generated data. In this scenario, SCIDP may evolve from a technical readiness protocol into a digital governance system for the surgical environment, provided that it advances together with formal research, auditing, and institutional maturation.

Professionally, the protocol helps give name and form to expertise often learned exclusively in practice. Naming this expertise is relevant because it makes it possible to describe, teach, evaluate, and recognize it. In a field in which invisible work sustains surgical fluidity, transforming tacit knowledge into documented knowledge is an epistemological and organizational gain. The conceptual contribution, therefore, is not limited to the technical content of the tower; it includes the very appreciation of a function of intraoperative reliability still insufficiently formalized in the country.

For these reasons, SCIDP deserves to be analyzed not only as a local protocol, but as a hypothesis for reorganizing technical support in minimally invasive surgery. Even if future validations modify parts of its architecture, the question it poses remains current: how can we ensure that the growing technological complexity of surgery is accompanied by equally mature processes of preparation, response, documentation, and learning? This book argues that this response necessarily involves intelligent standardization.

DATA GOVERNANCE, PREDICTIVE MAINTENANCE, AND DIGITAL SURGERY

The digital transformation of the operating room increases the relevance of protocols such as SCIDP. Network recording systems, integration with electronic medical records, connected towers, robotic platforms, and instruments capable of generating telemetry create a new scenario: in addition to the reliability of the equipment itself, the reliability of the data produced, stored, and eventually reused for teaching, auditing, and performance analysis also becomes important. In such environments, apparently small failures—for example, loss of timestamp, incomplete recording, or incorrect case identification—cease to be mere inconveniences and begin to have clinical, financial, legal, and scientific impact.

The original name of SCIDP already contains this intuition by referring to capture and documentation. Documentation is treated in an expanded sense: technical record, operational metadata, chain of custody of information, and the possibility of learning from events. When the institution is able to relate equipment incidents, maintenance logs, parameters used in surgery, and process outcomes, it approaches a higher level of analytical maturity. This movement is still incipient in most Brazilian hospitals, but it tends to gain strength with the consolidation of digital surgery.

Data governance, however, requires caution. Not all captured data are useful, and excessive information can produce documentary fatigue without generating real learning. The recommended principle is that of minimum analytical sufficiency: record enough to understand patterns, assign responsibility to processes, and guide maintenance, without transforming the protocol into an unfeasible bureaucratic apparatus. This means prioritizing fields that make it possible to answer concrete questions: Which component failed? At what stage? With what effect? Was there backup? How much time was lost? Information that does not support decisions tends to become noise.

Digital maturity also opens the way to predictive maintenance. If an institution accumulates a history of failures by component, intensity of use, maintenance date, type of surgery, and room, it can begin to predict degradation more accurately than by a simple fixed calendar. The Ministry of Health manual already valued documentation and maintenance planning; the contemporary advance lies in connecting this logic to near-real-time usage data. In the medium term, protocols such as SCIDP may function as a structured capture layer for more sophisticated predictive maintenance systems (BRASIL, 2002).

Interoperability is also becoming increasingly important. In complex hospitals, records from the operating room, clinical engineering, quality, and the medical record often remain fragmented. The technical incident is recorded in one spreadsheet; maintenance, in another system; surgical delay, in an operational report; and the clinical outcome, in the medical record. This fragmentation prevents systemic learning. A promising future agenda consists of connecting, even through simple integration, SCIDP

records to these different information environments. The gain is not merely administrative; it improves understanding of causality and the institutional cost of failures.

Artificial intelligence applied to surgery, currently expanding, depends on reliable databases. Models for video analysis, recognition of operative stages, event detection, and decision support may be compromised if the infrastructure for capture, recording, and labeling is fragile. From this perspective, technical readiness and documentation protocols are not only mechanisms of immediate safety; they are prerequisites for more sophisticated digital ecosystems. Without basic standardization, analytical ambition risks relying on inconsistent data.

From an ethical standpoint, digitalization reinforces the need for clarity regarding access, retention, confidentiality, and secondary use of information. The technical documentation proposed by SCIDP must be treated in accordance with institutional policies on information security and data protection, especially when associated with surgical images and patient identifiers. This requires shared governance among the operating room, clinical engineering, information technology, quality, and legal counsel. Technically sound protocols may generate new risks if they neglect this informational dimension.

In summary, digitalization does not make SCIDP obsolete; on the contrary, it increases its relevance. The more connected, automated, and analytical the operating room becomes, the more necessary a robust layer of technical-operational standardization becomes, capable of ensuring readiness, data integrity, traceability, and integration among processes. The future of the protocol, therefore, does not lie in remaining restricted to a paper checklist, but in serving as the basis for progressively more sophisticated digital governance.

Table 10

Possible evolution of SCIDP in digital maturity

Stage	Characteristics	Typical infrastructure	Main risk
Initial	Checklist and paper records	Printed forms and spreadsheets	Data loss and low integration
Intermediate	Local digital records	Structured spreadsheets / electronic forms	Information silos
Advanced	Integration with clinical engineering and quality	Dashboards and institutional databases	Insufficient data governance
Expanded digital	Interoperability and analytics	Medical record, equipment logs, BI	Dependence on inconsistent data

Source: Prepared by the author.

FINAL OBSERVATIONS ON INSTITUTIONALIZATION OF THE PROTOCOL

In addition to the appendices, it is recommended that each institution develop a concise local manual derived from the protocol, containing photographs of the equipment actually used, naming conventions, physical location of backup components, escalation contacts, and particularities of each room. Many incidents arise less from absolute lack of knowledge and more from contextual uncertainty: the professional knows what to do in theory, but loses time looking for the correct component, confirming nomenclature, or verifying which cable is compatible with a given tower. The local manual reduces this cognitive friction.

The preparation of this local material may be seen as a stage in the organizational translation of SCIDP. Mature protocols do not circulate only as a central text; they materialize in posters, onboarding routines, equipment labels, backup signage, and standardized nomenclatures. This materiality is important because it makes the protocol visible in physical space and helps maintain adherence over time. In contexts of high turnover and multiple shifts, what does not acquire visible form tends to depend excessively on the memory of a few individuals.

Another practical recommendation is the incorporation of brief meetings for regular review of technological incidents. Unlike extensive and sporadic committees, these meetings should focus on patterns, repeated causes, and feasible corrective actions. The objective is to create a short circuit between recording, analysis, and institutional response. When professionals perceive that the data collected generate real changes—component replacement, flow review, training reinforcement—the legitimacy of the protocol grows and the perception of unproductive bureaucracy decreases.

There is also pedagogical value in building a database of exemplary cases. Successfully resolved incidents, recurrent failures, configuration errors, and examples of good communicational escalation can be anonymized and used in continuous training. In terms of knowledge management, real cases function as a bridge between abstract norms and concrete practice. They help new professionals recognize patterns and veterans review decisions from an analytical perspective. This case database constitutes one of the most tangible expressions of organizational learning defended by SCIDP.

CONCLUSION

Throughout this expanded edition, it has been argued that the technical reliability of video-assisted surgery must be treated as a component of care quality and patient safety. International literature, normative documents, and Brazilian experience in clinical engineering converge toward the same conclusion: technology without process is organized vulnerability. The contemporary operating room depends on integration among equipment, team, communication, and documentation; when this integration fails, delays, improvisations, and avoidable risks increase (WHO, 2009; WEERAKKODY et al., 2013; ANVISA, 2013).

In this scenario, the SCIDP Protocol was repositioned in this work as a technical-operational standardization framework for intraoperative support in video-assisted surgery systems. Its pillars—preventive diagnosis, immediate intervention, and multisystem adaptability—were articulated with checklist, traceability, training, and indicator-based evaluation instruments. More than a set of verifications, the protocol was presented as a governance proposal applied to the real use of surgical technology.

The work also sought to separate rigorously what constitutes consolidated evidence from the literature and what remains preliminary evidence derived from the author's operational records. This distinction is crucial to the scientific maturity of the project. Robust protocols are born from practice, but they become stronger when they accept the path of validation, criticism, and refinement. The merit of this work lies in giving academic form to a relevant practice and in offering a conceptual basis for its future evaluation.

If contemporary surgery is increasingly technological, good surgical practice must be equally capable of governing that technology. The patient benefits not only from the skill of the operator; the patient also benefits from the stability of the system that supports that skill. SCIDP is a contribution to that stability. Its future development will depend on multicenter research, institutional improvement, and recognition that specialized intraoperative technical support is not an accessory, but part of the architecture of safe, efficient, and traceable surgery.

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APPENDIX A – COMMENTED MODEL OF A TECHNICAL PREOPERATIVE CHECKLIST

This appendix presents an expanded model of a technical preoperative checklist for video-assisted surgery systems. Its purpose is to offer an operational basis that can be adapted to the reality of each institution without losing the logic of the protocol. The checklist does not replace the universal surgical checklist or the nursing checklist; it adds a specific layer of verification of the tower, accessories, multibrand integration, and backup readiness. The experience described throughout this work suggests that the instrument's greatest utility lies not only in checking items, but in structuring the reasoning of the responsible professional and reducing dependence on individual memory in pressure-filled environments (WHO, 2009; ROMAIN et al., 2012).

The proposed model organizes checking into seven blocks. The first block is identificatory: date, time, room, team, responsible surgeon, specialty, and procedure. The second concerns physical integrity: condition of cables, connectors, lenses, monitors, pedals, filters, hoses, and supports. The third concerns basic functionality: power supply, system initialization, peripheral recognition, correct input selection, recording test, and insufflator response. The fourth block concerns compatibility: coupling of optic, camera head, cables, light source, and accessories. The fifth concerns configuration: white balance, image profile, light, pressure, and flow parameters, when applicable. The sixth concerns contingency: existence of critical reserve components and ease of access. The seventh is documentary: signature of the executor, observations, and final release decision with or without reservations.

Pedagogically, it is recommended that the checklist initially be used as a commented instrument. During the training phase, the professional responsible for technical support must understand why each item exists, which failure it seeks to avoid, and what immediate corrective action is expected when the item is nonconforming. One of the most common weaknesses in checklist implementation is the transformation of the checklist into a mechanical ritual. When this occurs, the list loses its cognitive value and becomes a mere formality. SCIDP seeks to avoid this risk by linking each item to a cause-and-effect logic.

It is also advisable to differentiate critical items from confirmation items. Critical items are those whose nonconformity prevents release of the system without correction or safe contingency—for example, absence of stable image, insufflator failure, lack of minimum backup, or relevant breach of physical integrity. Confirmation items are those that, although important, may allow documented reservations or a previously agreed alternative plan. This gradation helps the team understand that not all nonconformities carry the same weight, but all must be recorded.

In institutions with digital resources, the checklist may be implemented in an electronic form with closed menus and automatic generation of indicators. In smaller services, the printed version remains fully viable. The indispensable requirement is not the technological support of the form, but its minimum completeness, archiving possibility, and retrieval for subsequent analysis. Ideally, each checklist should be associated with the procedure performed and the set of equipment actually used, allowing historical consultation by room, equipment, specialty, and professional.

Form A1

Technical preoperative checklist (summary model)

Block	Verification item	Compliant	Noncompliant	Observation
Identification	Procedure, team, room, and time confirmed	□	□	
Integrity	Cables and connectors without visible damage	□	□	
Integrity	Optic clean and without apparent defect	□	□	
Functionality	Image tested and stable on main monitor	□	□	
Functionality	Light source operating and adequate intensity	□	□	
Functionality	Insufflator tested according to specialty	□	□	
Compatibility	Camera, optic, and cables mutually compatible	□	□	
Configuration	White balance and image profile checked	□	□	
Contingency	Critical backup available and identified	□	□	
Documentation	Executor recorded reservations and released the system	□	□	

Source: Prepared by the author.

APPENDIX B – TEXTUAL TROUBLESHOOTING MATRIX BY PROBLEM FAMILIES

This appendix describes the operational troubleshooting logic of SCIDP. Instead of complex graphic flowcharts, a textual matrix was chosen, oriented by symptom, dominant hypothesis, first verification, second verification, contingency, and escalation condition. The objective is to facilitate training, rapid consultation, and institutional adaptation. The literature on laparoscopic troubleshooting indicates that response to frequent problems improves when there is a predictable order of checking, reducing time wasted on scattered hypotheses or high-cost interventions before simple and safe attempts (SIDDAIAH-SUBRAMANYA; NYANDOWE; TIANG, 2017).

For total image loss, the recommended sequence begins with physical connection and correct video-input selection; proceeds to verification of the light source, camera head, and integrity of the optic; and, if the problem persists, moves to a previously prepared backup unit. For progressive image degradation, priority is given to assessment of the lens, cleaning, condensation, fiber-optic cable, heating, and processor parameters. For insufflation failures, gas connection, hoses, filters, trocar sealing, programmed pressure, and insufflator alarm are checked. In arthroscopy and endoscopy, the logic is adapted to the distension medium or corresponding platform.

The troubleshooting matrix should be trained by problem families, not only by equipment brand. This principle increases the transferability of the protocol. In multibrand services, training exclusively in the commands of a single manufacturer may generate excessive dependence and reduce resilience in the face of substitutions. Training by problem families—signal loss, light failure, recording failure, distension failure, accessory incompatibility—allows the professional to maintain structured reasoning even when the device interface changes. Manufacturer specificity remains necessary, but as a complementary layer.

Another key element is the definition of cut-off points for escalation. Some problems can be resolved autonomously in seconds, with no need to interrupt surgery; others require immediate communication to the surgeon and nursing team; still others require a joint decision on a longer pause, platform replacement, or technical conversion. Recording these cut-off points avoids expectation conflicts

and reduces the risk of underreporting important incidents. In a high-criticality environment, clearly defining who decides what is itself part of patient safety.

The final recommendation is that each institution review its flows at least every six months, in light of actual incidents observed. Troubleshooting flowcharts must be living documents. If a problem recurs and is not covered, the matrix must be updated. If a given step adds no value or unduly prolongs the response, it must be reviewed. The usefulness of SCIDP depends on this capacity to learn from experience without losing methodological discipline.

Matrix B1

Troubleshooting by initial symptom

Symptom	First verification	Second verification	Contingency	Escalation
Total image loss	Cables / video input	Light source / camera	Camera or monitor backup	Notify surgeon if > 60–90 s
Darkened image	Light source / optical cable	Brightness configuration	Replace cable/source	Escalate if no immediate improvement
Blurred image	Lens / condensation	Optic / focus	Replace optic	Assess brief pause
Recording failure	Media / storage	Software / case identification	Alternative record	Communicate documentary impact
Loss of pneumoperitoneum	Hose / connection	Valves / trocars / pressure	Replace component	Notify if it interferes with dissection

Source: Prepared by the author.

APPENDIX C – COMPONENT TRACEABILITY AND SERVICE-LIFE FORM

The traceability and service-life form proposed by SCIDP has a dual function: documentary and predictive. Documentary, because it records the trajectory of the component from its entry into operation until disposal; predictive, because it allows wear trends to be recognized before frank failure. Cables, optics, connectors, light sources, and camera heads show degradation patterns that may be perceived only when the history is analyzed longitudinally. The absence of this technical memory favors reactive maintenance and the repetition of avoidable events (BRASIL, 2002; IEC, 2014).

The minimum form must contain unique identification of the component, manufacturer, model, serial number, date of entry into operation, main sector of use, preventive maintenance performed, corrective repairs, associated incidents, and date of disposal or replacement. A field for standardized subjective assessment of performance after use is also recommended, especially for items whose degradation is not immediately measurable by a simple test. This assessment does not replace formal calibration, but it helps capture progressive loss of perceived quality.

When associated with the intraoperative occurrence record, the form allows useful correlations. For example, if a given camera head concentrates episodes of intermittent signal loss and has already undergone previous repairs, the decision for preventive replacement becomes more justified. Likewise, if fiber-optic cables from a specific batch show recurrent loss of brightness, the institution can renegotiate the contract, review the supplier, or redefine acquisition policy. Thus, traceability surpasses the archival function and begins to influence strategic decisions.

In hospitals without a mature computerized system, a well-structured spreadsheet can provisionally fulfill this role. What matters is that fields are consistent and that there is a formally responsible person for updating them. Traceability without update governance quickly deteriorates. For this reason, the protocol recommends appointing an institutional technical manager and providing for periodic audits of completeness. Only in this way does the form cease to be a dead archive and become an operational intelligence tool.

Form C1

Component traceability form

Field	Description / completion
Unique identification	Internal code, manufacturer, model, serial number
Category	Optic, cable, camera head, monitor, light source, insufflator, etc.
Entry into operation	Date of incorporation and main sector of use
Maintenance events	Preventive, corrective, calibrations, responsible supplier
Associated occurrences	Reference to linked intraoperative records
Performance assessment	Condition after use and standardized observations
Final destination	Replacement, disposal, asset write-off, or reserve

Source: Prepared by the author.

APPENDIX D – MINIMUM SCIDP TRAINING CURRICULUM

SCIDP implementation requires a training program organized in levels. The introductory level should cover foundations of clinical engineering, patient safety, architecture of the laparoscopic tower, notions of asepsis, and integration with surgical flow. The intermediate level should explore multibrand compatibility, white balance, insufflation parameters, identification of recurrent failures, and standardized documentation. The advanced level should address troubleshooting under pressure, communication in critical events, situational leadership, indicator analysis, and participation in audits. This progression prevents training from being restricted to “learning by doing” without a common conceptual basis.

Simulation occupies a central role in this curriculum. Image loss, recording failure, cable disconnection, monitor breakdown, insufflator alarm, and absence of a backup component can be reproduced in a controlled environment so that the team can train diagnosis and communication without exposing patients to risk. In parallel, interprofessional simulation is recommended with participation by nursing and, when possible, surgeons, in order to rehearse not only the technical solution, but also moments of escalation and joint decision-making. This design brings training closer to reality and strengthens cooperation among professions.

Competency assessment should combine theoretical testing, observational checklist in simulation, and supervised performance assessment in real cases. The professional qualified for SCIDP is not merely the one who memorizes steps, but the one who executes the appropriate sequence, maintains clear communication, records correctly, and demonstrates situational awareness. Institutionally, internal certification should have temporal validity and require retraining after the introduction of new equipment or after a prolonged period away from the function.

It is also recommended that the curriculum include modules on ethics, data protection, limits of professional action, and interface with institutional sectors. In digital environments, intraoperative technical support increasingly deals with sensitive information, images, and system integration. The protocol executor needs to know not only what to do technically, but what may or may not be accessed, recorded, and shared. This dimension is indispensable to the maturity of the function.

Finally, the training program must generate permanent material: protocol manual, summary pocket version or technical poster, database of exemplary incidents, and onboarding pathway for new members. In institutions with high turnover, this teaching collection is the main mechanism for preserving organizational knowledge. Without it, each departure of an experienced professional tends to make the protocol regress toward improvisation.

Table D1

Minimum SCIDP training curriculum

Module	Suggested workload	Contents
Foundations	8 h	Clinical engineering, patient safety, surgical terminology
Tower architecture	8 h	Image, light, insufflation, component integration
Troubleshooting	12 h	Failure families, intervention windows, backup
Documentation and indicators	6 h	Checklist, technical occurrence, dashboard
Interprofessional simulation	8 h	Critical scenarios with communication and escalation
Supervised practice	20 h or more	Application in real cases with preceptor

Source: Prepared by the author.

APPENDIX E – MINIMUM DASHBOARD AND INDICATOR LOGIC

The minimum SCIDP dashboard was designed to provide a managerial view without losing adherence to routine. It is recommended that five groups of indicators be monitored monthly. The first group measures coverage: percentage of eligible procedures followed by the protocol and percentage of complete checklists. The second measures reliability: technical failures per 100 procedures, distribution by type of failure, and recurrence by component. The third measures time: mean resolution time, pauses longer than one, three, and five minutes, and nonproductive time associated with incidents. The fourth measures readiness: functional availability of towers, proportion of critical backups available, and updated traceability. The fifth measures learning: number of corrective actions implemented, training sessions conducted, and emerging audit themes.

The interpretation of these indicators requires methodological caution. A simple reduction in reported failures may mean real improvement, but it may also indicate underreporting. Therefore, indicators must be read together. If reported failures decrease, but documentation completeness also decreases, the data are suspect. If the number of failures remains the same, but mean resolution time decreases and availability increases, there may be a real gain in resilience. The culture of analysis must be contextual and nonpunitive, prioritizing trends and causes over simplistic judgments.

In hospitals with greater analytical maturity, the dashboard may include stratification by room, specialty, surgeon, shift, and type of platform. This granularity helps locate specific vulnerabilities. However, caution is recommended regarding nominative use of data, especially in early phases. The protocol's objective is to improve processes, not produce punitive rankings of people. Personalization of indicators should occur only when there is clear ethical governance and a focus on learning.

Visual presentation also matters. Useful indicators are those that can be quickly understood by surgical coordination, clinical engineering, and the patient safety center. Trend graphs, compliance traffic lights, and synthetic tables of critical incidents usually work better than extensive spreadsheets. The dashboard does not replace in-depth analysis, but it creates a common language among sectors. This shared language is one of the less visible but more strategic gains of any standardization protocol.

Finally, it is recommended that SCIDP indicators be incorporated, whenever possible, into existing institutional governance. When they remain isolated in a technical niche, their managerial influence tends to be small. When they dialogue with the safe surgery committee, clinical engineering, quality, and care management, they become part of the hospital's decision-making architecture. This is the desired maturity stage: the protocol ceases to be an individual initiative and becomes an operational policy of the institution.

Table E1

Minimum SCIDP dashboard

Indicator	Suggested initial target	Periodicity	Responsible for analysis
Adherence to technical checklist	> 85%	Weekly / monthly	Operating-room coordination
Technical failures per 100 cases	Baseline + trend	Monthly	Technical support + quality
Mean resolution time	Progressive reduction	Monthly	Technical support
Pauses > 5 min due to technical failure	Decreasing trend	Monthly	Medical / nursing coordination
Functional availability of towers	> 95% when feasible	Monthly / quarterly	Clinical engineering
Corrective actions executed	Cycle closure > 70%	Quarterly	Safety / management committee

Source: Prepared by the author.

APPENDIX F – INSTITUTIONAL PILOT-PROJECT MODEL

As an initial adoption strategy, SCIDP can be implemented through a twelve-week pilot project. The first week is devoted to institutional alignment, definition of the internal sponsor, and selection of the pilot specialty. Weeks two and three focus on local diagnosis and customization of forms. Weeks four and five are dedicated to theoretical-practical training. Weeks six to ten correspond to supervised implementation, with weekly review of records. Weeks eleven and twelve are intended for consolidation of indicators, analysis of lessons learned, and executive presentation to management.

The pilot should have modest and measurable objectives. Instead of promising broad reduction of complications, it is recommended to focus on goals such as achieving adherence above 85% to the technical checklist, reducing mean resolution time of events, increasing availability of critical backup, and improving documentation of occurrences. Specific goals increase the chance of success and generate concrete institutional evidence for eventual expansion. The project must also designate individuals responsible for data collection, review, and presentation; without this governance, the pilot tends to dissolve into routine.

At the end of the pilot, it is useful to produce a report divided into four parts: context and baseline; description of implementation; quantitative and qualitative results; recommendations for scaling. The report should include examples of incidents resolved, practical difficulties encountered, adjustments made to forms, and an estimate of resources needed for expansion. This implementation documentation is as important as the numbers themselves, because it helps transfer learning to other rooms and teams.

If the institution decides to scale the protocol, gradual expansion by waves is recommended, rather than simultaneous implementation in all environments. Expansion by waves allows supervision to be maintained, preserves training quality, and corrects deviations before they spread. In terms of change management, this approach usually generates greater adherence and less resistance, especially in services where the culture of technical checklists is still incipient.

Table F1

Synthetic schedule for a 12-week pilot project

Weeks	Main deliverables
1	Institutional sponsorship, definition of specialty and pilot team
2-3	Local diagnosis, inventory, and documentary customization
4-5	Theoretical training, simulation, and interprofessional alignment
6-10	Supervised implementation and weekly review of records
11-12	Consolidation of indicators, executive report, and expansion decision

Source: Prepared by the author.

APPENDIX G – PROPOSAL FOR MULTICENTER SCIENTIFIC VALIDATION

For more robust scientific validation of SCIDP, this appendix proposes a prospective multicenter stepped implementation design. The study could include hospitals of different sizes, with minimum eligibility criteria related to surgical volume, existence of standardizable towers, and availability of data collection. The suggested primary outcome is the rate of intraoperative technical failures per 100 eligible procedures. Secondary outcomes may include mean resolution time, technical pauses longer than three and five minutes, cancellations due to technological failure, functional availability, and the team's perception of cognitive overload and work organization.

Data collection should combine standardized SCIDP instruments, completeness auditing, and a single glossary of failures. The absence of a homogeneous taxonomy is one of the main obstacles to comparison among studies. It is proposed that incidents be classified into availability, integration, configuration, physical integrity, and traceability, as discussed in the body of the book. Each incident could also receive a grading of process impact: no delay, minor delay, significant pause, need for equipment replacement, cancellation, or technical conversion.

In analytical terms, a quasi-experimental design with historical baseline or stepped implementation by centers tends to be more feasible than a classic randomized trial. What matters is ensuring transparency in the definition of the pre- and post-periods, standardizing eligibility criteria, and controlling, when possible, relevant concomitant changes, such as renewal of the technological equipment base or additional surgical training. Publishing the instruments as appendices and the analytical protocol in an open repository would increase the credibility of the investigation.

In addition to quantitative indicators, a qualitative component is recommended. Interviews or focus groups with surgeons, nursing, anesthesia, technical support, and managers may reveal gains and tensions that numbers alone do not capture. Issues such as trust in the team, perception of readiness, reduction of conflicts, and clarity of roles often emerge in these approaches. In organizational protocols, understanding actors' experiences is decisive for explaining why implementation works in one place and encounters resistance in another.

The multicenter study could also serve to refine the very concept of intraoperative technical support. Today, this function is operationalized in very different ways across institutions. Documenting the real scope of activity, training profile, workload, hierarchical insertion, and interface with clinical engineering would help transform a diffuse practice into a more visible field of knowledge. SCIDP, in this sense, is simultaneously an object of validation and a tool for describing an emerging occupation.

Table G1

Suggested structure for a multicenter validation study

Element	Proposal
Design	Stepped implementation or prospective historical comparison
Centers	Hospitals of different sizes with active video-assisted surgery
Primary outcome	Intraoperative technical failures per 100 procedures
Secondary outcomes	Resolution time, long pauses, availability, team perception
Instruments	SCIDP checklist, occurrence record, traceability form, interviews
Analysis	Time series, pre-post comparison, qualitative component

Source: Prepared by the author.

APPENDIX H – ETHICAL AND LEGAL CONSIDERATIONS

The implementation of an intraoperative technical protocol raises ethical and legal questions that deserve explicit treatment. First, confusion between technical support and clinical decision-making must be avoided. The SCIDP executor does not decide surgical indication nor replace the surgeon's authority, but informs, prepares, intervenes technically, and documents occurrences within the sphere of his or her competence. This delimitation must appear in institutional rules to reduce ambiguity and conflict in critical situations.

Second, protocol records may form part of incident investigations, audits, and quality programs. Therefore, the institution must define a clear policy for access, storage, retention, and sharing of this information. When there is association with surgical images, metadata, or patient identifiers, information protection becomes even more sensitive. Documentation should not be seen as the private archive of a sector, but as a formal component of care governance.

Third, an institutional nonpunitive culture for honest incident reporting is essential. Safety protocols fail when records are used primarily to search for culprits. This does not mean absence of accountability; it means differentiating intentional or negligent behavior from systemic failures, insufficient training, and process-design problems. The patient safety literature consistently shows that punitive environments reduce reporting and compromise organizational learning (REASON, 2000; WHO, 2009).

Finally, any expansion of SCIDP toward broad data collection, multicenter research, or advanced digital integration must observe applicable ethical approval and compatibility with institutional regulations. The robustness of an innovative protocol depends both on its operational effectiveness and on its ethical and documentary legitimacy. Protocol governance, therefore, must grow in parallel with its reach.

Table H1

Ethical and governance issues associated with the protocol

Theme	Guiding question	Minimum recommendation
Competence	Who decides technically and who decides clinically?	Institutional standard with clear roles
Data access	Who may consult records and images?	Access policy and audit trail
Reporting	How can reporting be encouraged without undue punishment?	Just culture and focus on process
Research	When is ethical submission required?	Assess integration with CEP/IRB according to scope
Retention	How long should technical records be kept?	Align with institutional policy and legislation

Source: Prepared by the author.

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