Statement of Research Interest

Prospective Validation of Station-Specific Risk Guidance for KLASS-Standardized Gastrectomy

Dear Professor Lee,

During KLASS-standardized gastrectomy, surgeons lack calibrated, patient-specific guidance on which lymph node stations require dissection. I propose a three-year doctoral program to build and prospectively validate a real-time, station-specific metastasis-risk tool that integrates intraoperative imaging with preoperative risk factors, with success measured not by accuracy alone, but by correlation with disease-free survival and KLASS-02-QC quality metrics.

Consider a 58-year-old patient undergoing robotic gastrectomy. Preoperative imaging suggests possible station 12a involvement, but intraoperative visualization is ambiguous. A surgeon relying on experience might skip the dissection to avoid hepatic artery injury (under-treatment) or pursue it aggressively at elevated risk of morbidity. A calibrated decision-support system could overlay a probability estimate (e.g., “Station 12a: 35% metastasis risk based on tumor characteristics and visual features”) directly on the console, converting intuition into quantified data that can be validated against outcomes.

State-of-the-art surgical AI reliably recognizes intraoperative anatomy, yet a critical gap remains: translating recognition into decisions that improve oncologic outcomes. The KLASS framework you have built, with standardized procedures, quality metrics, and prospective registries, creates the ideal environment to close this gap. I am applying to target a September 2027 PhD start, and my RCT coordination experience, technical preparation, and our co-authored publication position me to execute this validation-first research.

Background and Preparation

My path to outcome-oriented surgical AI began with hands-on validation experience. As principal research coordinator for the ENiMoN trial, I managed an 80-patient randomized controlled trial evaluating enhanced non-invasive monitoring in robot- assisted nephrectomy. My responsibilities included patient recruitment, perioperative data collection, regulatory documentation, and coordination with faculty supervisors. This experience taught me rigorous data governance, the challenges of signal processing under OR constraints, and a core conviction: decision-support tools must prove clinical benefit through prospective validation, not just retrospective accuracy.

During 11 weeks on your service at Seoul National University Hospital (February–April 2025), I observed 97 advanced procedures and worked within the KLASS ecosystem. I saw firsthand the recurrent, codifiable decision points, plane identification, tissue handling, completeness of D2 dissection, where consistent guidance could reduce

variability. Our co-authored publication on bariatric surgery outcomes in Prader-Willi Syndrome demonstrated that we can collaborate productively.

SNUH offers what this research requires: high surgical volume under standardized KLASS protocols, mature prospective registries, established quality metrics (KLASS-02- QC), and your leadership in function-preserving gastrectomy. No other environment combines these elements for rigorous AI validation.

Why This Research, Why Now, Why Me

Why now: The technical prerequisites are in place. AI anatomy recognition achieves reliable performance on surgical video; prospective registries have matured; the KLASS framework provides standardized procedures and quality benchmarks. What's missing is the validation step, linking AI outputs to patient outcomes. The field is ready to move beyond accuracy metrics.

Why here: This research cannot be conducted remotely. Daily immersion in surgical workflow, real-time access to OR video, and longitudinal relationships with the clinical team are essential. Germany has strong methodological training, but lacks the high- volume KLASS-standardized gastrectomy environment and registry infrastructure that SNUH provides. The research question demands this specific setting.

Why me: I bring validation methodology from the ENiMoN trial, clinical insight from 97 observed procedures on your service, and the conviction, learned firsthand, that decision-support tools must prove outcome-level benefit. I have demonstrated ability to implement published methods independently (surgical video segmentation pipeline, survival analysis tools) and will deepen these skills before arrival. My primary contributions will be validation methodology, statistical analysis, and clinical integration, complemented by collaboration with your lab's computational team for advanced implementation.

Research Questions

1. **Station-risk reasoning:** Can station-specific lymph-node metastasis risk be estimated from preoperative variables and registry outcomes strongly enough to guide KLASS-standardized surgical planning?
2. **Video-derived surgical features:** Can intraoperative gastrectomy video features — anatomy visibility, exposure, and quality signals — improve or calibrate those risk estimates beyond clinical variables alone?
3. **External validation pathway:** Can preliminary public laparoscopic-to-robotic transfer work on CholecSeg8k/SISVSE be translated into valid SNUH robotic-gastrectomy evidence after IRB approval, privacy review, and permissioned data access?

Research Vision: Three-Year PhD Program

Primary Goal: Close the gap between AI capability and clinical utility by delivering station-specific risk prediction for KLASS-standardized gastrectomy, validated prospectively against survival outcomes and quality metrics.

Aim Structure: Aim 1 (risk prediction models) is the core deliverable. Aim 2 (quality metric correlation) uses the same data infrastructure and is synergistic. Aim 3 (multimodal fusion) establishes feasibility for post-doctoral work rather than serving as a primary PhD outcome.

Importantly, negative results are also valuable within this framework. If intraoperative visual features fail to improve prediction beyond preoperative factors, or if automated quality metrics do not correlate with survival, these findings provide evidence-based boundaries for surgical AI deployment, demonstrating where the technology does not yet warrant clinical integration. A validation-first approach produces actionable knowledge regardless of direction.

Aim 1: Station-Specific Risk Prediction Models (Primary)

Objective: Develop and validate station-specific lymph node metastasis risk models that provide calibrated probability estimates suitable for clinical decision support.

Approach: A tiered modeling strategy with increasing complexity:

1. **Baseline Model:** Penalized logistic regression (LASSO/elastic net) integrating preoperative factors (tumor size, depth, location, histologic type), with regularization to prevent overfitting given expected event counts of 15-30 per station. Validated against published nomograms (e.g., Kim et al., Endoscopy 2020; Memorial Sloan Kettering nomogram).

2. **Visual Integration:** Extract intraoperative features from surgical video frames using a fine-tuned ResNet-50 backbone, testing whether visual information adds predictive value beyond preoperative factors alone.
3. **Calibration Focus:** Apply temperature scaling and isotonic regression to ensure probability outputs reflect true event rates, prioritizing reliable decision support over maximal discrimination.

Sample Size & Feasibility: Based on published station-specific metastasis rates of 15- 25% for intermediate-risk stations, a cohort of 150-200 cases (accumulated across Years 1-2) provides approximately 25-50 events for stable model estimation per station. Initial Year 1 cohort (60-80 cases) will establish baseline calibration with acknowledged uncertainty; full validation requires the complete prospective cohort. For stations with lower metastasis rates (<10%), event counts may be insufficient for individual station models even with penalization; in these cases, stations will be grouped by anatomic region to achieve stable estimation.

Success Metrics:

- **Discrimination:** AUC matching or exceeding published nomograms (0.75–0. range per Kim et al., 2020)
- **Calibration:** Brier score approaching 0.15 with Expected Calibration Error (ECE) <0.10—thresholds consistent with well-calibrated clinical prediction models (Steyerberg & Vergouwe, *Eur Heart J* 2014)
- **Clinical Coherence:** Model predictions align with known clinicopathologic risk factors; no paradoxical associations

Aim 2: Outcome-Linked Quality Metrics (Synergistic)

Objective: Determine whether automatically extracted intraoperative quality metrics correlate with oncologic outcomes, establishing which metrics warrant inclusion in real- time feedback systems.

Approach:

1. **Metric Selection:** Extract pre-specified quality indicators from synchronized video and device telemetry: thermal injury events, dissection plane integrity, lymph node yield per station, and operative time per phase. These metrics align with KLASS-02-QC quality standards established for perioperative outcomes (Song et al., Ann Surg 2023).
2. **Automated vs. Manual Extraction:** Compare algorithm-extracted metrics against expert video review (two independent raters with adjudication) to

establish extraction reliability (target: ICC >0.80 for continuous metrics; Cohen's κ >0.70 for categorical metrics).

3. **Outcome Correlation:** Using the SNUH prospective registry, correlate validated metrics with oncologic outcomes via multivariable Cox regression, adjusting for stage, comorbidities, and adjuvant treatment.

Timeline Consideration: Patients enrolled in Year 1 will have 2-year follow-up available by dissertation completion. Patients enrolled in Year 2 will have shorter follow- up; analyses will use available follow-up time with appropriate censoring, acknowledging that mature survival data for the full cohort extends beyond the PhD period.

Success Metrics:

- **Primary:** At least one automatically-extracted quality metric independently associated with disease-free survival (HR with 95% CI excluding 1.0) on multivariable analysis
- **Secondary:** Extraction reliability meeting pre-specified thresholds (ICC >0.80; κ >0.70)
- **Exploratory:** Surgeon-level variation in quality metrics (descriptive analysis within SNUH)

Aim 3: Multimodal Fusion Pilot (Exploratory)

Objective: Establish technical feasibility for integrating ICG lymphatic mapping with station-specific risk models, generating preliminary data for post-doctoral research.

Scope Clarification: It depends on successful completion of Aims 1-2 infrastructure and will be scaled according to available time and resources. Full multimodal fusion with real-time guidance is post-doctoral scope; this aim establishes whether the approach warrants further investment.

Approach:

1. **Synchronized Capture Protocol:** Develop workflow for simultaneous RGB and ICG-NIR video acquisition during D2 lymphadenectomy, coordinating with existing OR equipment and SNUH protocols.
2. **Feasibility Assessment:** Pilot synchronized capture in 20-30 cases, documenting technical challenges, capture success rate, and processing requirements.

3. **Preliminary Signal Exploration:** Correlate ICG fluorescence patterns with pathologic nodal status at the station level (exploratory analysis, hypothesis-generating only).

Success Metrics:

- **Primary (Feasibility):** Successful synchronized capture in ≥20 cases with documented protocol
- **Secondary (Technical):** Staged development from offline analysis → near-real- time prototype → workflow-integrated evaluation. Latency targets to be determined empirically based on surgical workflow requirements.
- **Exploratory:** Descriptive correlation between ICG intensity and nodal metastasis

Timeline and Milestones

Year 1: Infrastructure and Baseline Models

Months 1-4: Institutional orientation, IRB approval, and data governance setup. Establish video capture protocols and registry linkage with SNUH systems.

Months 5-12: Begin prospective collection of synchronized RGB video, device telemetry, and outcomes from KLASS-standardized gastrectomies. Target: 60-80 cases by year-end.

Technical Development: Implement baseline risk models (logistic regression with preoperative factors) and deploy open-source anatomy recognition algorithms to establish baseline quality metrics. Pre-register all inferential analyses before accessing outcome data.

Year 1 Deliverables:

- Functional data capture and storage pipeline
- Baseline model with preliminary calibration assessment (acknowledging that stable estimates require Year 1-2 combined cohort)
- Pre-registered statistical analysis plan
- First-author methods paper describing validation framework (target submission)

Year 2: Model Integration and Feasibility Testing

Model Development: Integrate intraoperative visual features (ResNet-50 backbone) with preoperative factors. Apply calibration methods (temperature scaling, isotonic regression) and evaluate on accumulating cohort (target: 150-200 total cases by Year 2 end).

Feasibility Study (N=60 prospective cases):

- **Design:** Single-arm prospective study with AI system providing risk estimates to research team (not displayed to operating surgeon in initial phase to avoid confounding).
- **Primary Endpoint:** System Usability Scale >70 (per Bangor et al., 2008 threshold for acceptable usability) based on surgeon feedback after reviewing AI outputs post-operatively.
- **Secondary Endpoints:** Technical stability (system uptime >95%), data completeness (>90% cases with complete capture), and extraction reliability benchmarks from Aim 2.
- **Exploratory:** Surgeon-reported decision impact ("Would this information have changed your approach?")

Year 2 Deliverables:

- Integrated risk model with formal calibration validation on full Year 1-2 cohort
- Completed feasibility study with usability and technical stability data
- Quality metric extraction pipeline with reliability validation
- Second paper: risk model validation results (target submission)

Year 3: External Validation Preparation and Dissertation

External Validation (Retrospective): Subject to your guidance on appropriate collaborators and timing, apply SNUH-trained models to a retrospective video cohort from one KLASS network hospital. Primary analysis: quantify domain shift (changes in AUC and calibration between sites) to inform generalizability.

Note: External validation scope depends on data availability and collaboration logistics. If external data access is delayed, Year 3 will focus on rigorous internal validation with subgroup analyses (by surgeon, tumor stage, procedure type) and sensitivity analyses.

Multimodal Pilot (Aim 3): If Aims 1-2 are on track, initiate ICG fusion pilot study (20- 30 cases).

Dissertation: Complete thesis documenting:

1. Validated station-specific risk models (Aim 1)
2. Outcome-linked quality metrics with extraction reliability (Aim 2)

3. Feasibility evidence for clinical deployment
4. External validation preliminary data or rigorous internal subgroup analyses

Year 3 Deliverables:

- Completed dissertation with publishable validation data
- Drafted multicenter protocol for post-doctoral grant applications
- Third paper: feasibility study results or external validation (target submission)

Data Governance and Regulatory Strategy

Data governance will follow GDPR and Korean Personal Information Protection Act (PIPA) standards with prospective informed consent. Site-level privacy impact assessments (PIAs) and data protection impact assessments (DPIAs) will be completed before data collection begins. All video data will undergo on-premises de-identification with automated face and PHI redaction before analysis or storage.

Versioned data documentation will specify modalities, frame rates, resolution, and ICG timing for reproducibility. Video labeling will use dual-rater annotation with formal adjudication protocols for disagreements. All inferential analyses will follow pre- registered protocols with published statistical analysis plans (SAPs) before any outcome data are accessed.

I will engage early with the Korean Ministry of Food and Drug Safety (MFDS) to understand regulatory pathways for AI-based surgical decision support, ensuring compliance requirements inform the research design from the outset.

Deliverables:

- De-identified, versioned multimodal dataset (available for KLASS network researchers per data sharing agreements)
- Validated decision-support prototype with documented API
- Pre-registered protocol and statistical analysis plan published before outcome analysis
- Open-source code repository for reproducibility

Technical Readiness and Skill Development

This AI-focused PhD requires computational skills I am actively developing. My current foundation includes:

- **Demonstrated:** Python programming, survival analysis (Cox regression, Kaplan- Meier via lifelines), model calibration (Brier score, ECE, Platt scaling), and reproducible ML workflows (Git, pytest)
- **Demonstrated:** Surgical-video segmentation workflow using DeepLabV3-ResNet50: validated CholecSeg8k benchmark work and preliminary SISVSE transfer evidence (zero-shot macro IoU 0.064 → fine-tuned macro IoU 0.491 on 480 public robotic-gastrectomy frames), demonstrating ability to implement and report reproducible computer-vision experiments honestly
- **Developing:** Real-time inference optimization and multimodal fusion, which represent areas where I will deepen expertise during the PhD

My strategy is explicit: I contribute validation methodology, statistical analysis, clinical integration, and regulatory navigation as primary responsibilities. For advanced computer vision implementation, I will collaborate with your lab's computational expertise. This division leverages my genuine strengths while ensuring technical feasibility.

Pre-PhD Development Roadmap (January 2026 – September 2027):

Phase Timeframe Focus

1 Months 1- 6 Complete Fast.ai Deep Learning curriculum; replicate one surgical segmentation paper from scratch

2 Months 7- 12 Remote collaboration with lab to establish data protocols (if possible); Replicate a second surgical AI paper; begin data protocol documentation.

3 Months 13- 14 Finalize GKS application, visa logistics; prepare IRB protocols for submission upon arrival

Funding Strategy

Funding Strategy: My primary goal is to secure the Global Korea Scholarship (GKS - University Track), which provides full tuition and living support; I am preparing the application for the next cycle.

Beyond GKS, I am exploring additional funding sources including DAAD programs and institutional scholarships. I would also welcome opportunities to contribute to ongoing laboratory projects, as early integration with the team would strengthen both the research relationships and the data infrastructure this work depends on.

Qualifications Summary

- **Validation experience:** Principal coordinator for 80-patient RCT with pre-registered analysis and regulatory documentation
- **KLASS familiarity:** 11 weeks embedded in your service; hands-on exposure to KLASS-02-QC metrics and standardized procedures
- **Technical foundation:** Python, survival analysis, model calibration—with emphasis on clinical reliability over raw accuracy
- **Proven collaboration:** Co-first author publication demonstrating productive working relationship
- **Commitment to integration:** Targeting TOPIK 3 by PhD start, TOPIK 4-5 by completion; prepared for full immersion in Korean academic and clinical culture

Long-Term Impact and Career Vision

This PhD aims to establish a validation framework requiring surgical AI to demonstrate prospective, outcome-level evidence before clinical deployment. By showing that AI guidance correlates with disease-free survival and quality metrics in KLASS- standardized gastrectomy, we create a model for evidence-based AI integration applicable beyond gastric cancer surgery.

Following this PhD, I plan to pursue surgical residency with a focus on GI oncology, with the goal of training at SNUH and building my career in Korea. My long-term vision is leading multicenter trials as junior faculty, proving not just that AI works technically, but that it improves patient outcomes. I am committed to contributing to the Korean surgical community long-term; I see Korea as my future professional home.

Closing

Professor Lee, your work establishing surgical quality standards through the KLASS framework provides the ideal platform for validating whether AI guidance correlates with survival, not just workflow efficiency. During my 11 weeks on your service, I observed the decision points where station-specific guidance could matter. I am prepared to spend three years converting that observation into rigorous evidence.

I would be honored to pursue this research under your mentorship.

Sincerely,

Maximilian Herbert Dressler

□ Related Projects

- [[business/termin-bot|Termin-Bot]]