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THE ROLE OF ONCO-INTERVENTIONAL RADIOLOGY IN MODERN HEALTHCARE

Ph.D. Thesis Booklet

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1. Introduction

1.1. Overview of the topic

1.1.1. What is the topic?

Onco-interventional radiology represents a rapidly evolving pillar of modern oncological care, integrating high-resolution imaging with minimally invasive, image-guided therapeutic procedures. Advances in cross-sectional imaging and ablative technologies have enabled precise, organ-preserving treatment strategies for both benign and malignant diseases, offering alternatives to conventional surgical or systemic therapies.

1.1.2. What is the problem to solve?

Despite increasing clinical adoption, many onco-interventional procedures remain unevenly evaluated, and robust comparative data against established surgical standards are limited. This uncertainty complicates clinical decision-making and guideline development, particularly in diseases where multiple therapeutic options coexist.

1.1.3. What is the importance of the topic?

Minimally invasive therapies have the potential to reduce morbidity, shorten hospital stay, and preserve quality of life while maintaining oncological efficacy. Establishing their role through systematic evidence synthesis is therefore essential for patient-centered, evidence-based care.

1.1.4. What would be the impact of our research results?

This thesis provides a structured evaluation of interventional radiological therapies in two clinically relevant settings: aldosterone-producing adrenal adenomas and low-to intermediate-risk prostate cancer. The results aim to support rational therapy selection and identify areas where further high-quality research is required.

2. Objectives

2.1. Study I. – Ablation and laparoscopic adrenalectomy: Balancing efficacy and safety in the treatment of benign adrenal gland tumors: A systematic review and meta-analysis

The aim of this study was to systematically compare laparoscopic adrenalectomy with minimally invasive interventional procedures in the management of benign adrenal tumors, focusing on perioperative complications and biochemical cure rates. Furthermore, we sought to assess if interventional approaches, such as ablation techniques, could replace laparoscopy as the preferred gold standard of care.

2.2. Study II. – Oncological Efficacy and Safety of Minimally Invasive Focal and Whole-Gland Interventions in the Treatment of Low- and Intermediate-Risk Prostate Cancer: A Systematic Review and Meta-Analysis

This review aims to evaluate the oncological effectiveness and safety of focal and whole-gland interventional therapies in the management of low- to intermediate-risk prostate cancer. We conducted a systematic review and meta-analysis of oncological, biochemical, and complication outcomes to provide an updated synthesis of the available evidence. Additionally, subgroup analysis was conducted to evaluate clinical differences between focal and whole-gland approaches.

3. Methods

Both studies were conducted as systematic reviews and meta-analyses in accordance with the PRISMA guidelines and the Cochrane Handbook recommendations. Study protocols were prospectively registered in the PROSPERO database.

3.1. Search Strategy

Comprehensive searches were performed in major biomedical databases without language restrictions. For both studies, MEDLINE (via PubMed), CENTRAL, and EMBASE were searched, while Scopus and Web of Science were additionally included for Study I.

3.2. Eligibility Criteria

3.2.1. Study I

Eligible participants were patients who underwent laparoscopic adrenalectomy or interventional radiological procedures for the treatment of early-stage adrenal gland tumors. Interventional techniques included cryoablation, radiofrequency ablation (RFA), microwave ablation (MWA), chemoablation, intravascular embolization, high-intensity focused ultrasound (HIFU), laser therapy, silicone gel therapy, and irreversible electroporation (IRE), which were compared with laparoscopic adrenalectomy. Eligible study designs included randomized controlled trials, cohort studies, and case–control studies. Studies were excluded if they were reviews, meta-analyses, systematic reviews, case reports, or case series. Non-comparative studies, preclinical or animal studies, and studies involving advanced or metastatic disease were also excluded. Conference abstracts and studies without accessible full-text articles were not considered.

3.2.2. Study II.

Studies were included if they enrolled patients undergoing interventional radiological treatment for low- or intermediate-risk prostate cancer. Eligible interventions comprised commonly used minimally invasive techniques, including HIFU, IRE, RFA, MWA, cryoablation, intravascular embolization, and chemical

ablation, applied either alone or in comparative settings. Eligible study designs included randomized controlled trials, prospective and retrospective cohort studies, case–control studies, and registry-based analyses. Studies were excluded if they were reviews, meta-analyses, systematic reviews, case reports, or case series, as well as preclinical or animal studies. Studies were also excluded if low- and intermediate-risk patients could not be distinguished from high-risk or metastatic cases, or if patients had received prior treatment. Conference abstracts and studies without accessible full-text articles were not considered.

3.3. Study selection and data extraction

In both studies, study selection and data extraction were conducted independently by two authors using EndNote X20.2 (Clarivate Analytics) and a standardized data extraction form. Any disagreements were resolved through discussion; if consensus could not be reached, a third reviewer was consulted, or the study authors were contacted for clarification.

3.4. Quality Assessment

Risk of bias was assessed using QUIPS tool for Study I and ROBINS-I or RoB 2 for Study II. The overall quality of evidence was evaluated, considering study design, heterogeneity, and methodological limitations.

3.5. Data synthesis and analysis

3.5.1. Study I

Statistical analyses were performed using R software with the meta package for all calculations and visualizations. Continuous outcomes were analyzed using mean differences with 95% confidence intervals, and missing summary statistics were estimated using established methods when necessary. Binary outcomes were evaluated using odds ratios calculated with the Mantel–Haenszel method under a random-effects model, applying the Paule–Mandel estimator and Hartung–Knapp adjustment. Heterogeneity was assessed using Cochran's Q test and the I^2 statistic, with publication bias explored through funnel plots and sensitivity analyses using the leave-one-out approach. Results were presented using forest plots, and statistical significance was defined as a p-value < 0.05.

3.5.2. Study II

Statistical analyses were performed using R software (version 4.1.3) with the meta and metafor packages. All analyses applied random-effects models with Hartung–Knapp adjustments to reduce the risk of false positive results. Statistical heterogeneity was assessed using Cochran's Q test and the I^2 statistic. Results were presented in forest plots with pooled effect estimates and corresponding 95% confidence intervals, and 95% prediction intervals were reported when applicable.

Complication, recurrence, and survival rates were logit-transformed, pooled using random-effects models, and back-transformed for presentation, while postoperative PSA outcomes were analyzed using mean values with established methods applied to estimate missing summary statistics. Sensitivity analyses were conducted using the leave-one-out approach, and statistical significance was defined as $p < 0.05$.

4. Results

4.1. Study I.

Five studies focusing on aldosterone-producing adenomas were included in our review. A total of 119 patients at 14 centers underwent ablation, and 161 patients had laparoscopic adrenalectomy. The complication rates (OR: 0.98, CI: 0.35–2.69) were similar in both groups, but among complications, hypertensive crisis (OR: 8.13; CI: 1.14–58.11) was more frequent in the ablative group, and even the success rate of interventions - the resolution of hypertension (OR: 0.30, CI: 0.16–0.56) - was lower in this group. On the other hand, the advantage of ablation was shorter intervention time (MD: 75.64 min; CI: 6.33–144.95), shorter hospital stay (MD: 1.6 days; CI: 0.88–2.31), and less perioperative blood loss (MD: 43.55 ml; CI: 12.07–75.04) compared to laparoscopy.

4.2. Study II

85 studies met the inclusion criteria, comprising 42 prospective cohort studies, 36 retrospective cohort studies, six registries, and one randomized controlled trial. Whole-gland HIFU showed significantly lower recurrence (15%) and postoperative mean PSA levels (0.68 ng/mL) than focal HIFU (24%, 2.81 ng/mL). Recurrence rates were similar for focal vs. extended IRE (30% vs. 26%) and focal vs. whole-gland cryoablation (18% vs. 13%). In-field and out-of-field recurrence rates were similar across treatment modalities (5–15%). Retreatment rates were low, with 6–7% of patients receiving a second ablation and 2–8% progressing to radical or hormonal therapy. Major complications were consistently rare. One-year biochemical recurrence-free survival (BRFS) exceeded 95%, and five-year BRFS approached 80% for HIFU and cryoablation.

5. Conclusions

5.1. Study I.

Laparoscopic adrenalectomy remains the gold-standard treatment for aldosterone-producing adenomas due to superior biochemical outcomes and a lower risk of hypertensive crisis. Minimally invasive ablation may represent a feasible alternative in selected patients, particularly when surgical risks are increased.

5.2. Study II.

IRE, cryoablation, and HIFU provide effective and safe focal and whole-gland treatment options for low- and intermediate-risk prostate cancer, with high survival and low major complication rates. Recurrence and postoperative PSA outcomes are comparable between focal and whole-gland IRE and cryoablation. In contrast, whole-gland HIFU provides better biochemical control and lower recurrence rates than focal HIFU, highlighting the importance of treatment extent in clinical decision-making.

6. Bibliography

6.1. Publications related to the thesis:

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Oncological Efficacy and Safety of Minimally Invasive Focal and Whole-Gland Interventions in the Treatment of Low- and Intermediate-Risk Prostate Cancer : A Systematic Review and Meta-Analysis

CANCERS 17: 17 Paper: 2863, 22 p. (2025)

Közlemény: 36333287 | Összefoglaló cikk (Folyóiratcikk) | Tudományos

Scopus - Oncology SJR indikátor: Q1

Scopus - Cancer Research SJR indikátor: Q2

IF: 4,4

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