

High-Intensity Theatre Lists for Robot-Assisted Thoracic Resection: a proof-of-concept series

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Abstract

Background

The high-intensity theatre (HIT) list model improves elective surgical throughput by eliminating inter-case turnaround time through parallel anaesthetic preparation. Its application to major anatomical thoracic resection has not previously been described.

Methods

Two prospective high-intensity theatre lists were conducted at a high-volume tertiary centre as a service evaluation. Fifteen patients underwent robot-assisted thoracic surgery for anatomical lung resection using the da Vinci Xi platform. Patients were pre-positioned in lateral decubitus in the anaesthetic room before entering theatre. Primary outcome was list completion rate; secondary outcomes included console time, turnaround time, complications graded by the Clavien-Dindo classification, length of stay, and 30- and 90-day mortality.

Results

List 1 comprised ten cases with two consultant surgeons operating simultaneously in two robotic theatres; List 2 comprised five cases with one surgeon. Briefing commenced at 07:30; knife-to-skin at 07:45. List 1 completed by 13:30 - ten major resections in 5 hours 45 minutes - with actual turnaround of 2–3 minutes between cases. All 15 procedures were completed (list completion 100%). Median console time was 35 minutes (range 23–56). All resections achieved R0 status. Complications occurred in 5 of 15 patients (33%): three grade II, one grade IIIb, one grade IVa by the Clavien-Dindo classification. Median length of stay was 4 days (range 1–30). Thirty-day and 90-day mortality were nil.

Conclusions

This is the first description of a HIT list for major anatomical thoracic resection. The model is safe, delivers a step change in theatre throughput without expanding resource, and warrants prospective multicentre evaluation.

Introduction

Lung cancer accounts for over 35,000 deaths annually in the United Kingdom and is the leading cause of cancer-related mortality [1]. The NHS Lung Cancer Screening Programme has increased the volume of early-stage diagnoses reaching surgical services, amplifying demand for timely resection [2]. Surgical delay carries direct oncological consequence: waiting beyond 4–12 weeks from diagnosis is associated with reduced overall survival in clinical stage I and II non-small cell lung cancer (NSCLC) [3, 4].

The High-Intensity Theatre (HIT) list operates on a single principle: two anaesthetic teams run in parallel, eliminating the interval between operations. While surgery proceeds in theatre, the next patient is induced and prepared in a dedicated anaesthetic room; on completion, the operated patient transfers directly to a second room for emergence, and the prepared patient enters theatre within minutes. First validated at Guy's and St Thomas' NHS Foundation Trust (GSTT) for robot-assisted radical prostatectomy (RARP), where four procedures were completed in a single day against a conventional maximum of three [5], the model has since been extended to plastic surgery, general surgery, orthopaedics, and ENT [6, 7, 8]. No application to major anatomical thoracic resection had been reported.

We describe the first two RATS HIT lists at a high-volume tertiary thoracic centre, detail the parallel workflow, and propose a patient selection framework.

Methods

These were the first two HIT lists for thoracic surgery at GSTT, designed prospectively as a proof-of-concept service evaluation. List 1 involved two consultant thoracic surgeons (Andrea Bille [AB] and Thomas Routledge [TR]) operating simultaneously in two adjacent robotic theatres, with ten patients scheduled. List 2 involved a single consultant (AB) in one theatre, with five patients scheduled. All procedures used the da Vinci Xi platform (Intuitive Surgical, Sunnyvale, CA) and were performed by the responsible consultant throughout; trainees assisted with robot docking, undocking, and port-site closure only. All vascular and bronchial structures were divided individually - pulmonary artery, vein, and bronchus each stapled separately. Systematic lymphadenectomy was performed in all cases; mean nodal yield was 6 (minimum three mediastinal stations).

The parallel workflow followed the model established at GSTT for urology (Fig. 1). Two consultant anaesthetists (Hani Abdalla and Imran Ahmed) staffed dedicated induction and emergence rooms with anaesthetic practitioners and scrub nurses. Each patient was pre-positioned in lateral decubitus and fully anaesthetised in Anaesthetic Room 1 before the preceding case ended - induction commenced when skin closure began in theatre. On completion, the operated patient transferred on the theatre trolley to Anaesthetic Room 2 (emergence bay, then post-anaesthetic care unit [PACU]); the pre-positioned patient entered theatre and was draped and docked within 2–3 minutes. Pre-positioning in the anaesthetic room saves approximately 15 minutes per case by running lateral decubitus positioning and double-lumen tube placement in parallel with the preceding operation. Team briefing: 07:30. Knife-to-skin: 07:45.

Eligibility required clinical stage I or II NSCLC planned for curative-intent anatomical resection, Eastern Cooperative Oncology Group performance status (ECOG PS) 0–1, and predicted post-operative forced expiratory volume in one second (FEV1) and transfer factor for carbon monoxide (TLCO) above thresholds for the planned resection. Exclusions: prior neoadjuvant chemotherapy or immunotherapy, redo or completion surgery, and planned elective high-dependency unit (HDU) or intensive therapy unit (ITU) admission. Ischaemic heart disease (IHD) with preserved left ventricular function was accepted;

impaired left ventricular function was an absolute exclusion. The patient selection algorithm is shown in Fig. 2.

Primary outcome: list completion rate (planned cases completed without unplanned cancellation). Secondary outcomes: console time, actual turnaround (skin closure to next-patient docking), post-operative complications (CD classification), LOS, and 30- and 90-day mortality. R-status was recorded for all resections. This service evaluation was approved by the departmental clinical governance lead at GSTT; no IRB or ethics committee submission was required under UK NHS governance.

Results

List completion was 100%; all 15 planned procedures were completed without unplanned cancellation or deferral. List 1 ran from 07:45 to 13:30 - ten major anatomical resections in 5 hours 45 minutes across two simultaneous robotic theatres staffed by two consultant surgeons. Actual turnaround was 2–3 minutes throughout. The sum of individual console times for List 1 was 354 minutes against a list duration of 345 minutes; this reflects the parallel workflow - non-console activity (port removal, drain, closure: approximately 15–20 minutes per case) runs concurrently with the next patient's induction in Anaesthetic Room 1, so effective list duration is less than the sum of console times.

Patient demographics and outcomes are presented in Table 1. Median age was 73 years (range 39–82); nine patients were female. ECOG PS was 0 in five patients (33%), PS1 in nine (60%), and PS2 in one (7%). Fourteen of 15 patients (93%) had at least one co-morbidity. Mean pre-operative FEV1 was 93% predicted; mean TLCO 82% predicted.

Procedures comprised ten lobectomies (67%), one bilobectomy, three segmentectomies, one trisegmentectomy, and one lobectomy with wedge resection. Adenocarcinoma was the diagnosis in 12 patients (80%). All 15 resections achieved R0 status. Pathological nodal stage was N0 in 13 patients (87%), N1 in one, N2 in one. Median console time was 35 minutes (mean 35, range 23–56). No conversion to open thoracotomy occurred.

Complications occurred in five of 15 patients (33%): three CD II (two hospital-acquired pneumonia [HAP], two prolonged air leak managed conservatively), one CD IIIb (pleural effusion requiring drainage with HAP; LOS 15 days), and one CD IVa (ECOG PS2 patient with IHD and impaired left ventricular function, chronic kidney disease, and COPD who developed post-operative sepsis, acute kidney injury [AKI], pleural effusion, cholecystitis, and cholangitis requiring ICU admission; LOS 30 days). Median LOS was 4 days (range 1–30). Thirty-day and 90-day mortality were nil; all 15 patients were alive and discharged at 90 days.

Table 1

Patient demographics and perioperative outcomes. LOS length of stay; CD Clavien-Dindo; HAP hospital-acquired pneumonia; AKI acute kidney injury; ICU intensive care unit; LUL left upper lobe; LLL left lower lobe; RLL right lower lobe; RUL right upper lobe

List	Pt	Age	Sex	Operation	Console (min)	Drain (d)	LOS (d)	Complications
1	1	39	M	Left upper lobectomy	32	1	3	Nil
1	2	56	M	Right lower lobectomy	33	1	4	Nil
1	3	68	F	Right bilobectomy (middle + lower)	56	1	15	Pleural effusion, HAP (CD IIIb)
1	4	69	F	Right lower lobectomy	33	2	4	Nil
1	5	69	F	Right lower lobectomy	29	3	6	HAP (CD II)
1	6	73	M	LUL bi-segmentectomy (S1 + S2)	33	1	3	Nil
1	7	76	F	LLL basal segmentectomy	33	6	8	Prolonged air leak (CD II)
1	8	78	F	RLL apical segmentectomy	29	1	2	Nil
1	9	79	M	LUL trisegmentectomy	49	3	6	Nil
1	10	79	F	Right upper lobectomy	27	1	3	Nil
2	1	62	M	Right lower lobectomy	38	1	1	Nil
2	2	73	M	Right middle lobectomy + wedge RUL	33	5	6	Prolonged air leak (CD II)
2	3	78	F	Right upper lobectomy	35	1	3	Nil
2	4	82	F	Left lower lobectomy	23	1	1	Nil
2	5	69	F	Right upper lobectomy	41	1	30	Sepsis, AKI, pleural effusion, cholecystitis, cholangitis (CD IVa) - ICU

Discussion

This series is the first report of a HIT list for major anatomical thoracic resection. Ten major RATS resections were completed in 5 hours 45 minutes on a single morning, with a 2–3 minute actual turnaround between cases. The throughput gain came entirely from eliminating dead time, not from operating faster - median console time of 35 minutes is consistent with or below published RATS benchmarks [9, 10, 11].

The mechanism is straightforward but requires discipline in execution. In conventional scheduling, 60–90 minutes separates skin closure from the next incision: recovery in theatre, reversal of anaesthesia, room turnover, ward-to-theatre transfer, re-induction. In the HIT model, none of these steps is sequential. Pre-positioning in the anaesthetic room - bringing the patient to lateral decubitus, inducing anaesthesia, and confirming double-lumen tube position before the preceding case ends - converts what was sequential time into concurrent time. This single step is the most consequential logistic decision in the thoracic HIT model. By the time the operated patient leaves theatre, the incoming patient has been anaesthetised for approximately 20 minutes and is ready for immediate entry. The 354-minute sum of console times against a 345-minute list duration reflects this overlap: non-console intra-operative activity runs in parallel with the next patient's induction, not after it.

The structural distinction between the two lists is important. List 1 deployed two consultant surgeons in two adjacent robotic theatres operating simultaneously - each running their own sequence of five patients. This is why ten cases were completed. List 2 was a single surgeon in a single theatre with five cases. Both models demonstrate the HIT principle, but List 1 represents a dual-stream deployment requiring specific theatre architecture.

Clinical outcomes are benchmarked in Table 2. Nil 30- and 90-day mortality, 100% R0, and median LOS of 4 days are consistent with published RATS series [9, 10, 11]. The overall complication rate of 33% reflects systematic CD grading including all grade II events; the CD III or above rate of 13% is within published RATS benchmarks. The single CD IVa complication occurred in an ECOG PS2 patient with multi-system co-morbidity and impaired left ventricular function - a profile that, in retrospect, supports firm exclusion from the HIT list regardless of acceptable single-organ reserve indices.

Table 2

Comparison of perioperative outcomes: current HIT list series versus published RATS and HIT list benchmarks. CD, Clavien-Dindo; RARP, robot-assisted radical prostatectomy.

Study	Specialty	N	Procedures	Complication rate	Mortality	LOS (median)
Louie et al. [9]	Thoracic (RATS)	40	Lobectomy	22.5%	0%	N/A
Hirose et al. [10]	Thoracic (RATS)	137	Lobectomy	CD ≥ III: 12.4%	~ 1%	5 days
Seder et al. [11]	Thoracic (RATS)	8,253	Lobectomy	27–28%	0.5–1.9%	5.8–6.5 days
Ahmed et al. [5]	Urology (HIT)	4/list	RARP	Equivalent	0%	N/A
Gianchandani et al. [6]	Plastic surgery (HIT)	49	Breast reconstruction	Flap failure: 2%	0%	3 days
Current series	Thoracic (RATS HIT)	15	Anatomical resection	CD ≥ II: 33%; CD ≥ III: 13%	Nil	4 days

The patient selection framework (Fig. 2) defines the intended cohort: stage I-II NSCLC, primary resection, ECOG PS 0–1, pulmonary function adequate for planned procedure, no prior systemic oncological therapy, no planned critical care admission. Lobectomy is the most reproducible procedure for the HIT context; segmentectomy is feasible but introduces technical variability. Pneumonectomy, sleeve resection, and bronchoplasty are currently excluded.

Maruthappu and colleagues demonstrated that repetition of the same procedure type on a list reduces operative time progressively, while switching procedure types increases duration [12]. The HIT list operationalises this by concentrating similar procedures with a consistent team. Ahmed and colleagues demonstrated an 80% reduction in 18-month waiting times in the GSTT urology programme since introduction of HIT lists in 2021 [5]. Gianchandani and colleagues applied the model to free flap breast reconstruction - mean operative time 279 minutes - with a 12.5-minute turnaround and acceptable morbidity [6]. Thoracic surgery was, until this series, the most complex specialty to which the model had not been applied.

Limitations: the series is small (n = 15) and single-centre; no matched comparator cohort was available; long-term oncological outcomes are not reported. The two-surgeon, two-theatre format requires specific hospital architecture - adjacent robotic theatres with shared anaesthetic room access - that is not universally available; capital reconfiguration may be prohibitive in older hospital stock. The single-surgeon, single-theatre model demonstrated in List 2 has no architectural dependency beyond a second anaesthetic room. Prospective multicentre validation is the necessary next step.

Conclusions

The HIT list can be applied safely to major anatomical thoracic resection. Ten RATS resections were completed in under six hours with nil 30- and 90-day mortality, 100% R0, and outcomes consistent with established RATS benchmarks. The throughput gain was achieved by eliminating inter-case dead time through parallel anaesthetic preparation and patient pre-positioning. In a specialty where surgical delay carries direct oncological cost, and in a healthcare system managing a substantial screening-driven increase in surgical demand, the HIT list represents a viable mechanism to protect curative intent without expanding resource.

Declarations

Competing interests:

None declared.

Ethical approval:

This was a service evaluation approved by the departmental clinical governance lead at Guy's and St Thomas' NHS Foundation Trust. Prospective data capture was undertaken for all cases. Under UK NHS governance, service evaluation does not require institutional review board (IRB) or research ethics committee approval.

Consent to participate:

Not applicable. This was a service evaluation; no individual patient consent for participation was required under UK NHS governance.

Consent to publish:

Not applicable. No individually identifiable patient data are presented.

Funding:

None.

Author Contribution

NB and MP contributed equally as joint first authors. AB, TR, AP: study conception, design, and surgical supervision. NB, MP: data collection and manuscript preparation. FA, CJ, GC, HA, IA: anaesthetic workflow design and execution. All authors reviewed and approved the final manuscript.

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Figures

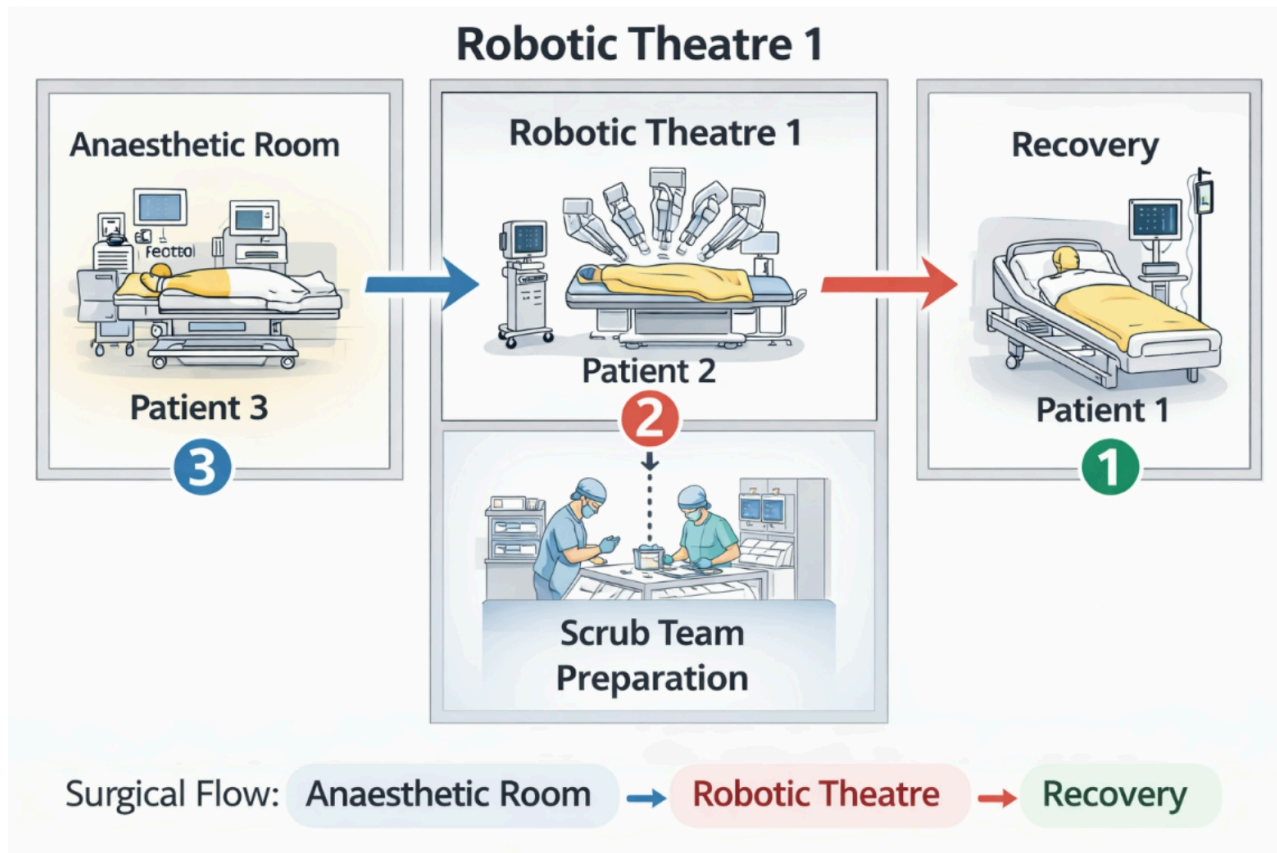


Figure 1

HIT list theatre workflow. While Patient N undergoes RATS in the robotic theatre, Patient N+1 is induced and pre-positioned in lateral decubitus in Anaesthetic Room 1. On completion, Patient N transfers intubated to Anaesthetic Room 2 (immediate emergence bay before PACU transfer); Patient N+1 enters theatre pre-positioned and is draped and docked within 2-3 minutes. Team briefing 07:30; knife-to-skin 07:45

Figure 2. Patient Selection Algorithm for Thoracic HIT Lists
— Guy's Hospital Framework —

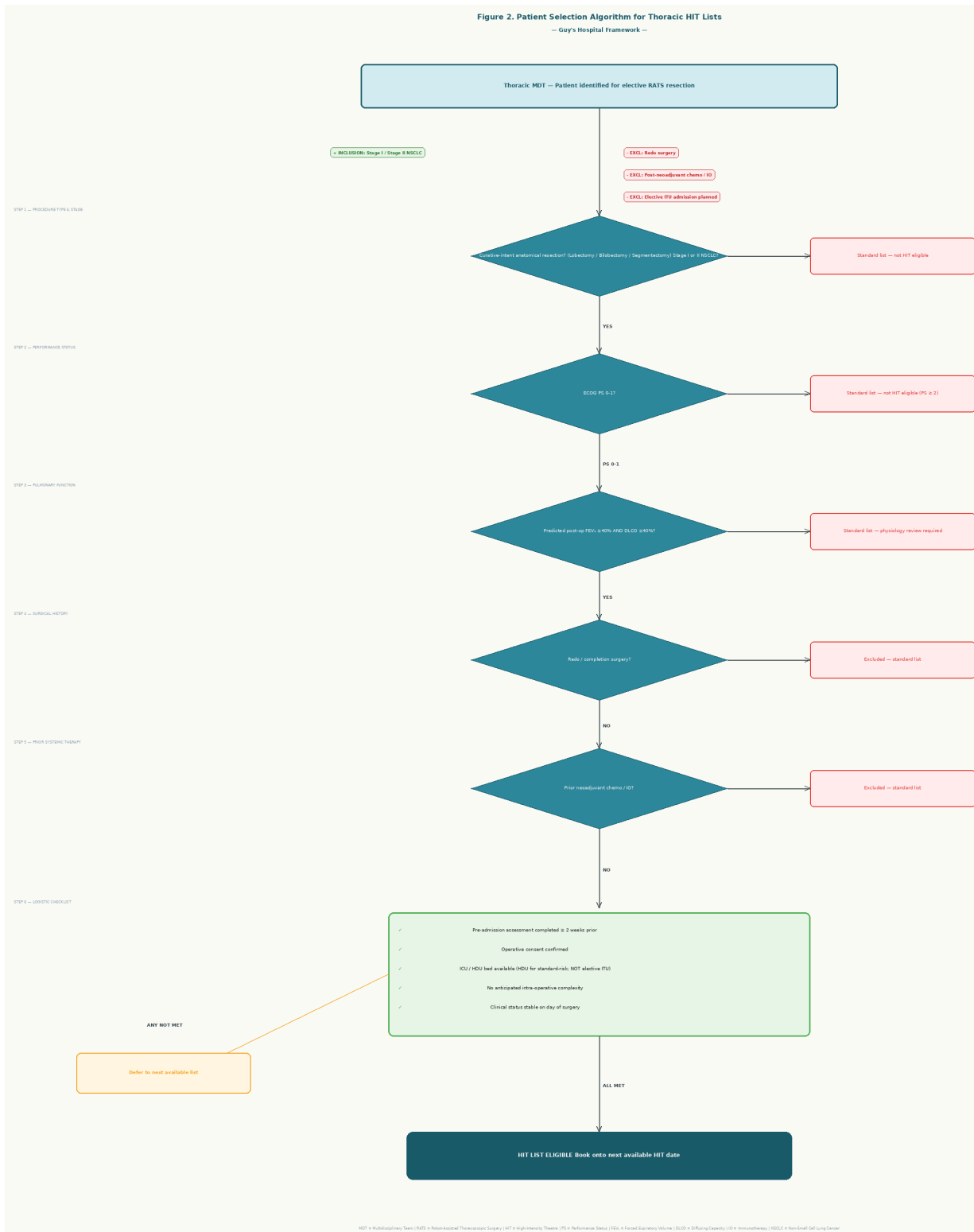


Figure 2

Patient selection algorithm for thoracic HIT lists. Patients are assessed across six domains: oncological suitability (stage I-II NSCLC, primary resection), procedure type (anatomical resection), performance status (ECOG PS 0-1), pulmonary function (predicted post-operative FEV1 and TLCO above accepted thresholds), surgical history (no prior redo or completion surgery), and systemic therapy history (no prior neoadjuvant chemotherapy or immunotherapy). IHD with preserved left ventricular function is accepted;

impaired left ventricular function is excluded. Numbers at each step reflect the current series (n=15 on list)