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Intraoperative Portal Vein Pressure and Post-Transplant Graft Outcomes in Adult Liver Transplantation: A Systematic Review

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ABSTRACT

Background: Intraoperative portal vein pressure (PVP) may reflect a mismatch between portal inflow and graft capacity after adult liver transplantation, but proposed thresholds vary and their clinical certainty is unclear.

Methods: We systematically searched PubMed/MEDLINE, Embase, CENTRAL, and Scopus from inception through March 2026 for adult liver-transplant studies reporting intraoperative PVP and postoperative graft outcomes. Two reviewers independently screened records and extracted data. Threshold/prediction studies were assessed with QUADAS-2, and certainty was evaluated using GRADE. Statistical pooling was not undertaken because the directly reported studies used different thresholds and analytical frameworks and may not represent independent cohorts.

Results: The search identified 1,247 records; 18 reports entered the qualitative synthesis. Three reports provided directly extractable threshold or prediction data. One comparative cohort reported SFSS in 1/39 recipients with final PVP <15 mmHg and 6/37 with PVP 15-19 mmHg. Two studies derived post-reperfusion thresholds of >16.5 and ≥17.5 mmHg, with sensitivities above 90% but materially different specificities. Risk of bias was high or unclear in key QUADAS-2 domains, and certainty was very low.

Conclusions: Higher intraoperative PVP is associated with small-for-size syndrome in adult living donor liver transplantation, but the available evidence does not establish a universal treatment threshold. PVP should be interpreted with graft size, venous outflow, donor and recipient factors, and local expertise. Prospective multicenter validation using prespecified thresholds and standardized outcomes is required.

Keywords: portal vein pressure, living donor liver transplantation, small-for-size syndrome, portal inflow, systematic review

INTRODUCTION

Liver transplantation remains the definitive treatment for end-stage liver disease and selected primary hepatic malignancies. Early graft dysfunction is a

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major source of postoperative morbidity and mortality, particularly when partial grafts are used in living donor liver transplantation (LDLT). In this setting, graft size alone does not explain outcome; the interaction between graft capacity, venous outflow, and portal inflow is also important (1-4).

Portal vein pressure (PVP) is an intraoperative hemodynamic measure of the balance between portal inflow and the vascular capacity of the graft. Excessive inflow can contribute to sinusoidal injury, impaired microcirculation, and the clinical phenotype of small-for-size syndrome (SFSS), characterized by cholestasis, coagulopathy, ascites, and graft dysfunction after technical causes have been excluded (1,2).

Clinical series have associated higher portal pressure with impaired regeneration or graft injury, and several centers have evaluated inflow-modulation procedures when PVP remains elevated (3-8). However, proposed thresholds range across approximately 15-20 mmHg, measurement timing is not uniform, and management decisions may themselves alter both the exposure and the outcome. Recent work also indicates that not every small graft requires portal-inflow modulation, emphasizing the importance of clinical context (7-9).

We therefore systematically reviewed studies that measured intraoperative PVP in adult liver transplantation and reported postoperative graft outcomes. The objectives were to describe the reported association between PVP and SFSS or related outcomes, assess the validity and certainty of proposed thresholds, and identify the limitations that prevent direct clinical standardization.

METHODS

Design, Reporting, and Protocol

This systematic review was prepared in accordance with PRISMA 2020 (10). The review question, eligibility criteria, and outcomes were defined before extraction. The protocol was not prospectively registered in PROSPERO and was not published; this departure from preferred prospective practice is reported as a limitation.

Eligibility Criteria

Studies were eligible when they met all of the following criteria:

- adult recipients (≥ 18 years) of living-donor, deceased-donor, or split liver transplantation;
- intraoperative PVP measured during the transplant procedure;
- PVP reported continuously or by a prespecified or data-derived threshold;
- at least one postoperative graft-related outcome, including SFSS, early allograft dysfunction, graft failure or survival, mortality, ascites, or related complications; and
- a full-text randomized or observational study published in English.

We excluded pediatric-only studies, animal studies, case reports or series with fewer than 10 participants, reviews, editorials, conference abstracts without usable data, hepatic-resection studies, studies limited to pretransplant portal-hypertension measurements, and duplicate reports that did not add distinct information. Potential cohort overlap was evaluated from center, recruitment period, author group, and clinical characteristics.

Information Sources and Search Strategy

PubMed/MEDLINE, Embase, the Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus were searched from inception through March 2026. Controlled vocabulary and free-text terms covered liver transplantation, portal pressure or portal hemodynamics, and graft outcomes. Reference lists of included reports and relevant reviews were also checked. Complete database-specific strategies are provided in Supplement 1; the PubMed strategy is reproduced there exactly to make the search auditable.

Study Selection and Data Extraction

Two reviewers independently screened titles and abstracts and then assessed potentially eligible full texts. Disagreements were resolved by discussion or, when required, a third reviewer. The same reviewers independently extracted study design, setting, sample size, transplant type, graft characteristics, timing and method of PVP measurement, portal-inflow interventions, threshold definition, SFSS definition, other outcomes, and directly reported numerical results. Adjusted estimates were preferred when valid and available.

Risk of Bias and Certainty of Evidence

Because the clinically actionable evidence concerned the performance or prognostic use of PVP thresholds, two reviewers assessed the three

threshold/prediction reports with QUADAS-2 (11). Judgments covered patient selection, the index test, the outcome reference standard, flow and timing, and applicability. The certainty of evidence for the association or prediction of SFSS was rated using GRADE principles for test and prognostic evidence (12). Disagreements were resolved by consensus.

Outcomes and Synthesis

The primary outcome was SFSS as defined by each study after exclusion of technical complications. Secondary outcomes were early graft dysfunction, graft or patient survival, mortality, ascites, and other reported postoperative complications. We planned quantitative synthesis only for sufficiently independent studies with comparable threshold definitions, measurement timing, outcome definitions, and extractable effect data.

Statistical pooling was not performed. The three reports with directly extractable threshold data used different PVP contrasts (a managed final-pressure stratum versus data-derived diagnostic cutoffs), differed in measurement and outcome frameworks, and arose from closely related clinical and author settings with possible participant overlap. Combining them as independent binary cohorts would therefore produce a clinically misleading summary. For the same reasons, hierarchical summary receiver-operating-characteristic analysis, pooled diagnostic odds ratios, likelihood ratios, meta-regression, and leave-one-out sensitivity analysis were not appropriate. With fewer than 10 independent studies, funnel-plot or regression-based publication-bias assessment was also not undertaken.

RESULTS

Study Selection

The database searches yielded 1,247 records; 892 remained after 355 duplicates were removed. After title and abstract screening, 76 full-text reports were assessed and 58 were excluded: 18 did not include intraoperative PVP measurement, 13 did not report eligible outcomes, 11 involved pediatric or non-transplant populations, eight were reviews or contained insufficient primary data, and eight were excluded for other prespecified reasons. Eighteen reports entered the qualitative synthesis, of which three provided directly extractable threshold or prediction data (*fig. 1*).

Study Characteristics and Threshold Findings

The evidence base was dominated by observational LDLT cohorts. Methods varied in graft selection, portal-pressure measurement, the use and timing of inflow modulation, and SFSS definition. Threshold-focused reports came from Egyptian adult LDLT programs and may include overlapping clinical populations; sample sizes and findings are therefore presented by report rather than summed as unique recipients (*table 1*).

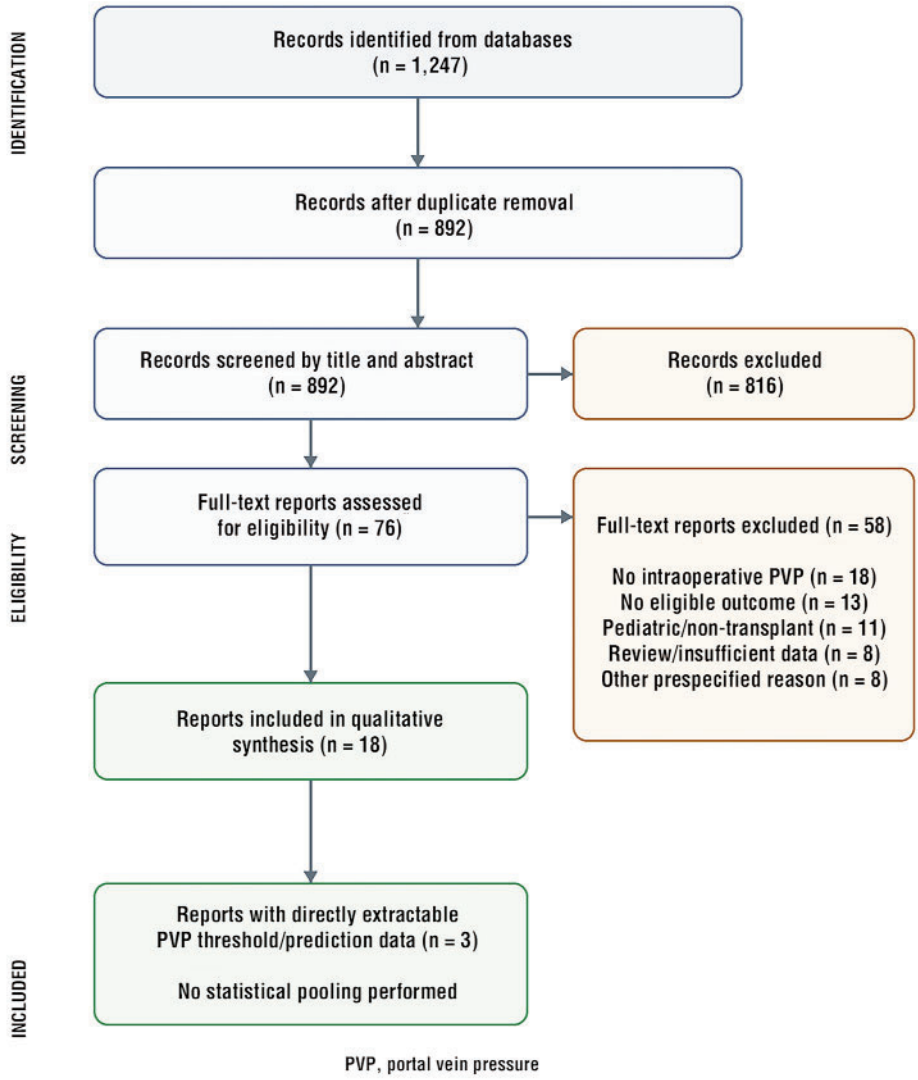
Osman et al. compared final PVP strata in 76 recipients: SFSS occurred in 1/39 with PVP <15 mmHg and 6/37 with PVP 15–19 mmHg; mortality occurred in 3/39 and 9/37, respectively (13). Sholkamy et al. analyzed 69 recipients and derived a post-reperfusion threshold >16.5 mmHg, reporting sensitivity of 91.7% and specificity of 50.5% for SFSS (14). Abdallah et al. analyzed 110 recipients and derived a threshold ≥17.5

Table 1 - Characteristics and directly reported portal-pressure findings

Study	Design and setting	Participants	PVP comparison or threshold	Directly reported findings
Osman et al., 2017 (13)	Comparative adult LDLT cohort; Egypt	n=76	Final PVP <15 mmHg (n=39) versus 15–19 mmHg (n=37)	SFSS: 1/39 versus 6/37 (p=0.040). Mortality: 3/39 versus 9/37 (p=0.047).
Sholkamy et al., 2018 (14)	Prospectively collected cross-sectional adult LDLT data; Egypt	n=69; SFSS n=15, no SFSS n=54	Post-reperfusion PVP; data-derived threshold > 16.5 mmHg	Mean PVP: 20.3±3.4 versus 16.9±5.0 mmHg. Sensitivity 91.7%; specificity 50.5%.
Abdallah et al., 2021 (15)	Retrospective adult LDLT cohort; Egypt	n=110; SFSS n=23, no SFSS n=87	Post-reperfusion PVP; data-derived threshold ≥ 17.5 mmHg	Mean PVP: 21.47±2.60 versus 13.29±3.60 mmHg. Sensitivity 91.3%; specificity 88.9%. Mortality: 47.8% versus 3.4%.

Abbreviations: LDLT, living donor liver transplantation; PVP, portal vein pressure; SFSS, small-for-size syndrome. The three reports differed in exposure definition, timing, and outcome framework; they were therefore not statistically pooled.

Figure 1 - PRISMA - style flow diagram



mmHg, with sensitivity of 91.3% and specificity of 88.9% (15). These values suggest an association between higher PVP and SFSS risk, but they do not validate a single interchangeable clinical cutoff.

Risk of Bias and Certainty

QUADAS-2 identified high or unclear risk in important domains (*table 2*). Patient selection was incompletely described, two thresholds were data-derived, blinding to the PVP measurement was not clearly reported, SFSS definitions were not fully uniform, and treatment decisions could be influenced by the measured pressure. Applicability concerns were moderate because all three threshold reports concerned adult LDLT within a limited

Table 2 - QUADAS-2 assessment of the threshold/prediction studies

Study	Patient selection	Index test	Reference standard	Flow and timing	Applicability concerns
Osman et al. (13)	Unclear	High	Unclear	Low	Moderate
Sholkamy et al. (14)	Unclear	High	Unclear	Low	Moderate
Abdallah et al. (15)	High	High	Unclear	Low	Moderate

Judgments were based on the information reported in each publication. Index-test bias was rated high because thresholds were selected, implemented, or evaluated without clearly documented prespecification and because portal-inflow management could be influenced by the measurement. Reference-standard reporting was insufficient to establish uniform, blinded application of an identical SFSS definition.

Table 3 - GRADE certainty assessment

Outcome	Evidence	Risk of bias	Inconsistency	Indirectness	Imprecision	Certainty
Association/prediction of SFSS by intraoperative PVP	3 observational reports	Very serious	Serious	Serious	Serious	Very low

The certainty was downgraded for nonrandomized, predominantly single-center evidence; inconsistent thresholds and measurement timing; indirectness to deceased-donor and non-Egyptian settings; possible participant overlap; and small event counts. No upgrading domain was met.

regional and practice context. GRADE certainty for PVP as a predictor of SFSS was very low (*table 3*). The rating reflected serious or very serious concerns about bias, inconsistency, indirectness, imprecision, and possible cohort non-independence. Consequently, the threshold estimates should be regarded as hypothesis-generating rather than practice-defining.

Sources of Heterogeneity

Clinically important heterogeneity arose from graft-to-recipient size, donor and recipient characteristics, portal and hepatic-venous flow, anesthesia and measurement conditions, the time point labeled as final PVP, the use of splenectomy, splenic-artery ligation or shunting, and differences in SFSS definition and follow-up. The small number of non-independent threshold reports made statistical investigation by subgroup analysis or meta-regression unreliable.

DISCUSSION

Across the available reports, higher intraoperative PVP was associated with SFSS in adult LDLT, but the evidence does not establish a universal threshold. The most directly reported values clustered between 15 and 17.5 mmHg (13–15). Their apparent agreement should be interpreted cautiously because the studies used different comparisons, two cutoffs were selected from the observed data, and the clinical populations may overlap.

The biological rationale remains plausible. A partial graft exposed to portal inflow beyond its vascular and metabolic capacity may develop sinusoidal stress and impaired regeneration (1–6). PVP, however, is not an isolated causal variable. Graft size and quality, hepatic-venous outflow, recipient severity, collateral circulation, anesthesia, and the choice and timing of portal-inflow modulation all affect the measured pressure and subsequent outcome. The pressure observed after an intervention is therefore partly a marker of physiology and partly a consequence of management.

Clinically, PVP is best interpreted as one part of intraoperative risk assessment, especially for small partial grafts. The evidence does not show that every recipient above a single value benefits from the same intervention. Reports questioning routine modulation in all small grafts favor a selective strategy that incorporates graft-to-recipient weight ratio, flow and outflow assessment, and the center's procedural experience (7,8). PVP-guided interventions should be individualized rather than treated as a mandatory response to an unvalidated cutoff.

The reviewer requested hierarchical SROC analysis, diagnostic odds ratios, likelihood ratios, sensitivity analyses, and meta-regression. Those methods require an adequate set of independent diagnostic-accuracy studies with compatible 2×2 data. The current evidence does not meet that condition: one report compared managed pressure strata, two evaluated data-derived thresholds, and study independence cannot be assured. A narrative synthesis with explicit risk-of-bias and certainty assessment is therefore more defensible than a numerically precise but invalid pooled estimate.

The review has limitations. The protocol was not prospectively registered, and only English-language full texts were eligible. Reporting in the underlying studies was incomplete, outcome definitions varied, and most evidence was single-center and observational. The three threshold reports may not represent independent patient samples. These limitations restrict generalizability beyond adult LDLT and preclude causal conclusions.

Future studies should prospectively enroll multicenter cohorts, prespecify the measurement time and threshold, document portal flow and hepatic-venous outflow alongside pressure, use a standardized SFSS definition, report management triggered by the measurement, and provide complete threshold tables. External validation should precede use of any value as a universal treatment trigger. Individual-participant-data collaboration may also help distinguish pressure effects from graft size and intervention selection.

CONCLUSION

Higher intraoperative portal vein pressure is associated with SFSS in adult living donor liver transplantation, but the certainty of evidence is very low and no universal treatment threshold can be recommended. PVP may inform risk stratification when interpreted with graft characteristics, venous outflow, recipient factors, and local expertise. Prospective multicenter validation using prespecified methods is needed before threshold-directed management can be standardized.

Conflicts of Interest

The authors declare no conflicts of interest.

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Supplementary Material

Supplementary material associated with this article can be found, in the online version.

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