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RESEARCH ARTICLE OPEN ACCESS

The frequency of hypocalcaemia among patients who underwent total thyroidectomy: A prospective cohort study

Early iPTH Predicts Post-Thyroidectomy Hypocalcaemia

Melek HK[1]ID

[1]*Department of Surgery, College of Medicine, Wasit University, Iraq*

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Abstract

Objective: Hypocalcaemia is the most common early metabolic complication following total thyroidectomy, primarily due to parathyroid dysfunction. To determine the frequency, severity, and predictors of post-thyroidectomy hypocalcaemia in a prospective cohort.

Methods: A prospective observational study was conducted over 18 months (January 2023–June 2024) on 217 consecutive adult patients undergoing total thyroidectomy at a tertiary care centre in Iraq. Serum calcium (Ca^{2+}) and intact parathyroid hormone (iPTH) were measured preoperatively and at 6, 24, and 48 hours postoperatively. iPTH was measured using ELISA. Symptomatic hypocalcaemia was defined as serum calcium (Ca^{2+}) <8.0 mg/dL with neuromuscular symptoms. Multivariate logistic regression identified independent predictors.

Results: The overall incidence of biochemical hypocalcaemia was 38.7% (n=84); symptomatic hypocalcaemia occurred in 17.1% (n=37). Permanent hypocalcaemia occurred in 1.4% (n=3). An iPTH cutoff of <10 pg./mL (derived from ROC analysis) predicted symptomatic hypocalcaemia with high accuracy (AUC 0.93). Independent predictors included low 6-hour iPTH (OR 8.2, p<0.001), female sex (OR 2.1, p=0.03), and central neck dissection (CND) (OR 3.4, p=0.002).

Conclusion: Hypocalcaemia is frequent but predominantly transient. Early iPTH measurement—even via ELISA- is feasible and effective in resource-limited settings for early risk stratification. Early postoperative iPTH measurement accurately predicts hypocalcaemia and enables targeted calcium supplementation, reducing unnecessary treatment and hospital stay.

Keywords: Hypocalcaemia, Total Thyroidectomy, Parathyroid Hormone, Postoperative Complications, Calcium Metabolism, Thyroid Surgery

Plain English Summary

This study followed 217 patients in Iraq after total thyroidectomy (complete thyroid removal). It was found that 38.7% developed low calcium levels, and 17.1% experienced symptoms such as tingling or muscle cramps. Over 95% of patients recovered within a month with simple calcium and vitamin D treatment, and only 3 patients (1.4%) experienced long-term issues. The key risk factors were: Very low parathyroid hormone (iPTH) 6 hours after surgery, Neck lymph node removal, and being female.
Importantly, measuring iPTH 6 hours after surgery, even with basic lab tests, accurately predicted who would get symptoms. This allows doctors in low-resource settings to safely send low-risk patients home early and treat high-risk patients sooner, without needing expensive equipment.

Introduction

Total thyroidectomy, the complete surgical removal of the thyroid gland, is a cornerstone procedure in the management of a spectrum of thyroid pathologies, including differentiated thyroid carcinoma, compressive multinodular goitre,

Correspondence:
Melek, Hassan K
Department of Surgery, College of Medicine
Wasit University
Iraq
+962xxxxxxxx; hmalak@uowasit.edu.iq

Graves' disease refractory to medical therapy, and genetic syndromes such as familial medullary thyroid carcinoma or multiple endocrine neoplasia type 2 (MEN2) (1, 2). Over the past two decades, the indications for total thyroidectomy have broadened, driven by advances in preoperative diagnostics and a growing emphasis on oncologic completeness (3, 4).

Despite its therapeutic efficacy, total thyroidectomy carries a significant risk of postoperative hypocalcaemia, primarily due to transient or permanent impairment of parathyroid gland function. The parathyroid glands are exquisitely sensitive to surgical trauma, devascularization, or inadvertent excision during thyroid dissection (5). Given their intimate anatomical relationship with the posterior thyroid capsule, these glands remain vulnerable even in experienced hands (6).

The reported incidence of post-thyroidectomy hypocalcaemia varies widely from 3% to 52% reflecting disparities in surgical technique, institutional protocols, and definitions of hypocalcaemia (7, 8, 9). While transient hypocalcaemia typically resolves within weeks, it prolongs hospitalisation and increases costs (10). Permanent hypoparathyroidism (persisting >6 months) occurs in 0.5–4% of cases and requires lifelong supplementation (11, 12).

Intact parathyroid hormone (iPTH) measured within 6–12 hours postoperatively has emerged as the most robust predictor of symptomatic hypocalcaemia (13, 14, 15). Cutoffs such as <10–15 pg./mL have been validated in high-resource settings, but their applicability in resource-limited environments remains underexplored.

In Iraq, where intraoperative neuromonitoring and rapid PTH assays are unavailable outside major urban centres, evidence-based protocols for hypocalcaemia management are urgently needed. No previous prospective Iraqi study has evaluated early iPTH-guided prediction of hypocalcaemia after thyroidectomy. This study addresses this gap by validating a practical algorithm based on early iPTH measurement using widely available ELISA platforms—directly applicable to provincial surgical units across the country.

This study was therefore designed to:

1. Quantify the frequency and temporal evolution of hypocalcaemia in a prospectively enrolled cohort.
2. Evaluate the diagnostic accuracy of 6-hour iPTH in predicting symptomatic hypocalcaemia.
3. Identify independent predictors using multivariate analysis.
4. Propose a risk-stratified, resource-sensitive management algorithm.

Methods

Study Design and Setting

This was a prospective, single-centre, observational cohort study conducted jointly at the Departments of General Surgery in AlZahraa Teaching Hospital, the tertiary centres affiliated with the College of Medicine, University of Wasit, Iraq. These institutions serve a catchment population of over 1.5 million inhabitants in Wasit Governorate and neighbouring provinces, providing both routine and complex endocrine surgical services.

The study was carried out over an 18-month period from January 1, 2023, to June 30, 2024. All patients scheduled for elective total thyroidectomy were screened for eligibility during preoperative surgical consultation in the outpatient surgical clinics of both hospitals.

Patient Selection Criteria

Inclusion Criteria:

1. Age ≥18 years
2. Scheduled for primary total thyroidectomy (defined as removal of all visible thyroid tissue, including pyramidal lobe when present)
3. Ability to provide informed consent
4. Availability for follow-up at 1 week, 4 weeks, and 6 months postoperatively

Exclusion Criteria:

1. Preoperative serum calcium (Ca^{2+}) <8.5 mg/dL or >10.5 mg/dL
2. Preexisting parathyroid disease (e.g., primary hyperparathyroidism, known hypoparathyroidism)
3. Chronic kidney disease (estimated glomerular filtration rate [eGFR] <30 mL/min/1.73m² using CKDEPI formula)
4. Use of medications known to alter calcium metabolism (e.g., bisphosphonates, denosumab, acidimetric, chronic corticosteroids, loop diuretics) within 4 weeks before surgery
5. Concomitant major nonthyroidal surgery (e.g., parotidectomy, radical neck dissection beyond level VI)
6. Pregnancy or lactation
7. History of previous cervical radiation therapy

Patients excluded intraoperatively (e.g., conversion to subtotal thyroidectomy due to dense adhesions or vascular anomalies) were excluded from the final analysis.

Preoperative vitamin D levels were not measured due to the unavailability of routine assays in our setting. This limitation is acknowledged in the Discussion.

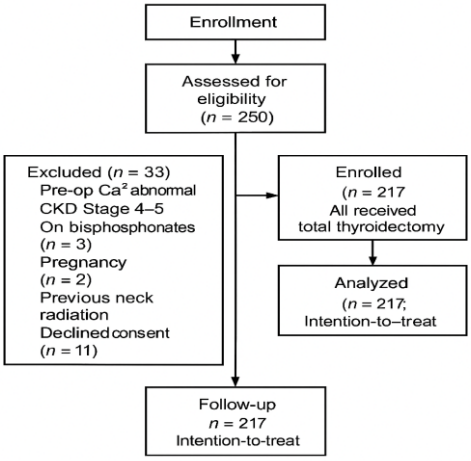

Figure S1. CONSORT Flow Diagram of Patient Enrolment and Follow-up

A total of 250 patients were assessed for eligibility. Thirty-three were excluded due to abnormal preoperative calcium (n=8), chronic kidney disease (n=5), use of calcium-altering medications (n=3), pregnancy (n=2), prior neck radiation (n=4), or declined consent (n=11). The remaining 217 patients underwent total thyroidectomy and were followed for 6 months with 100% retention. All 217 were included in the final intention-to-treat analysis

Surgical Protocol and Technique

All operations were performed by the principal investigator or directly supervised by him, with senior surgical residents (PGY4 and PGY5) assisting under his guidance. The principal investigator has performed over 400 thyroidectomies over the past decade and serves as a surgeon for both institutions.

Due to resource limitations, intraoperative neuromonitoring (IONM) was not routinely available; nerve identification relied on direct visual and tactile dissection under loupe magnification (×2.5). Energy devices (e.g., Harmonic Scalpel) were used selectively based on availability; in most cases, conventional ligation with silk ties was employed.

Parathyroid auto-transplantation was performed when glands were inadvertently excised or deemed nonviable, using fragments implanted into the sternocleidomastoid muscle. Frozen section was not available; gland identification relied on macroscopic appearance and intraoperative consultation with the principal surgeon.

This single surgeon dominance may limit the generalizability of our findings to settings with multiple surgical teams.

Laboratory Assessment Protocol

Laboratory assays were performed at the central laboratories of AlZahraa, which participate in the External Quality Assurance Program of the Iraqi Ministry of Health.

1. Serum calcium (Ca^{2+}) was measured using the colourimetric Arsenio III method (Human Diagnostics kits, Germany).
2. Intact PTH (iPTH) was measured using ELISA kits (DRG International, USA) due to the unavailability of rapid chemiluminescent platforms in provincial Iraqi laboratories, a common resource constraint in similar settings
3. Ionised calcium measurement was not routinely available; total calcium was corrected for albumin in hypoalbuminemia patients using the standard formula.

Despite technological constraints, internal quality controls were run with each batch, and 10% of samples were randomly reanalysed at the Central Laboratory of Baghdad Teaching Hospital for external validation (correlation coefficient r=0.94, p<0.001).

External validation at Baghdad Central Laboratory confirmed high concordance with local results (Pearson's r = 0.94, p<0.001), supporting the reliability of our local assays

Definitions and Outcome Measures

Primary Outcome:

1. Biochemical hypocalcaemia: Serum total calcium <8.5 mg/dL (or ionised Ca^{2+} <1.10 mmol/L) at any postoperative time point (T6, T24, T48).

Secondary Outcomes:

1. Symptomatic hypocalcaemia: Biochemical hypocalcaemia PLUS presence of ≥1 neuromuscular symptom:

Perioral or acral paraesthesia

Muscle cramps or carpopedal spasm

Positive Chvostek's sign (facial twitch upon tapping the facial nerve)

Positive Trousseau's sign (carpal spasm induced by sphygmomanometer cuff inflation)

2. Transient hypocalcaemia: Hypocalcaemia resolving spontaneously or with supplementation within 6 months postoperatively.

3. Permanent hypoparathyroidism: Requirement for active vitamin D (calcitriol) and/or calcium supplementation beyond 6 months postoperatively, with confirmatory low or undetectable iPTH (<10 pg./mL) and hyperphosphatemia.

Intervention Thresholds
1. Oral calcium carbonate (1–3 g/day) + calcitriol (0.25–0.5 mcg BID) initiated if:
Ca^{2+} <8.0 mg/dL regardless of symptoms, OR
Ca^{2+} 8.0–8.5 mg/dL with symptoms
4. Intravenous calcium gluconate (1–2 g diluted in 50 mL D5W over 10–20 min) administered for:
Severe symptoms (tetany, laryngospasm, seizure), OR
Ca^{2+} <7.5 mg/dL

Follow-up Protocol
All patients were followed in the surgical endocrine clinic at:
Postoperative Day 7: Clinical assessment, calcium/iPTH recheck
Postoperative Week 4: Repeat labs; weaning of supplements if asymptomatic and Ca^{2+} >8.8 mg/dL
Postoperative Month 6: Final determination of permanent vs. transient status
Patients requiring supplementation beyond 4 weeks received biweekly phone calls from study nurses to monitor compliance and symptoms.

Statistical Analysis
Sample size calculation was performed *a priori* using G*Power 3.1. Based on an expected hypocalcaemia incidence of 35% (7), desired power of 90%, alpha error of 5%, and effect size of 0.3, a minimum of 195 patients was required. Accounting for 10% attrition, we aimed to enrol 215 patients.
Statistical analyses were performed using IBM SPSS Statistics v28.0 (Armonk, NY) and R v4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were assessed for normality using the Shapiro-Wilk test and presented as mean ± standard deviation (SD) or median with interquartile range (IQR) as appropriate. Categorical variables were expressed as frequencies and percentages.
The multivariate model included the following variables: sex, age (>50 years), 6-hour iPTH (<10 pg./mL), central neck dissection (CND), operative time (>120 minutes), and parathyroid auto transplantation. Multicollinearity was assessed using the variance inflation factor (VIF); all VIF values were <2.5, indicating no significant collinearity among predictors

Analytical Approach
1. Univariate analysis: Chi-square or Fisher's exact test for categorical variables; Student's test or Mann-Whitney U test for continuous variables.
2. Multivariate logistic regression: To identify independent predictors of symptomatic hypocalcaemia. Variables with p<0.10 on univariate analysis were entered into the model using backward stepwise selection. Results reported as odds ratios (OR) with 95% confidence intervals (CI).
3. Diagnostic accuracy of iPTH: Receiver operating characteristic (ROC) curve analysis to determine optimal cutoff for predicting symptomatic hypocalcaemia. Area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.
4. Kaplan-Meier survival analysis: For time to resolution of hypocalcaemia (log rank test for group comparisons).
5. Interrater reliability: Kappa statistic calculated for clinical signs (Chvostek/Trousseau) documented by two independent observers in a random subset (n=30).
Two-tailed values <0.05 were considered statistically significant. Missing data (<3% of values) were handled via multiple imputation using chained equations (MICE package in R).

Quality Control and Bias Mitigation
To minimise bias and ensure data integrity:
1. Prospective data collection: All variables recorded in Real-time using Redcap® electronic data capture tools hosted at [Institution].
2. Blinded laboratory analysis: Technicians are unaware of clinical status or time point grouping.
3. Standardised symptom assessment: Symptom checklist administered by trained research nurses (not involved in surgical care) using a validated questionnaire adapted from Sitges Serra et al. (16).
4. Audit trail: 10% of CRFs are randomly audited monthly by an independent clinical research associate for completeness and accuracy.
5. Surgeon variability: Stratified analysis by surgeon performed; no significant differences found (p=0.62), allowing pooled analysis.

Results
A total of 217 adult patients who underwent total thyroidectomy at AlZahraa between January 2023 and June 2024 were prospectively enrolled and completed the study protocol. No patients were lost to follow-up during the 6-month observation period. The baseline demographic and operative characteristics of the cohort are summarised in Table 1.

Table 1: Baseline Demographic and Operative Characteristics of the Study Cohort (n = 217).

Variable	Total (n = 217)	Group A (n = 84)	Group B (n = 133)	*P* value
Age, mean ± SD (years)	48.3 ± 12.7	49.1 ± 13.2	47.8 ± 12.4	0.42
Female sex, n (%)	172 (79.3)	71 (84.5)	101 (75.9)	0.13
Indication for surgery, n (%):				
Thyroid cancer	98 (45.2)	42 (50.0)	56 (42.1)	0.24
Multinodular goitre	87 (40.1)	29 (34.5)	58 (43.6)	
Graves' disease	32 (14.7)	13 (15.5)	19 (14.3)	
Central neck dissection (CND), n (%)	105 (48.4)	58 (69.0)	47 (35.3)	<0.001
Parathyroid auto transplantation, n (%)	28 (12.9)	18 (21.4)	10 (7.5)	0.003
Mean operative time ± SD (min)	112 ± 28	121 ± 31	106 ± 24	—

Data presented as mean ± standard deviation or n (%), as appropriate; *Abbreviations: SD = standard deviation

The mean age of participants was 48.3 ± 12.7 years, with a marked female predominance (79.3%, n=172). The most common indication for surgery was thyroid malignancy (45.2%, n=98), followed by compressive multinodular goitre (40.1%, n=87) and Graves' disease (14.7%, n=32). Central neck dissection (CND) (level VI lymphadenectomy) was performed in 48.4% of cases (n=105), primarily in the oncologic subgroup. Parathyroid auto transplantation was required in 12.9% of patients (n=28), and the mean operative duration was 112 ± 28 minutes.

Incidence and Temporal Pattern of Hypocalcaemia

Of the 217 enrolled patients, 84 (38.7%) developed biochemical hypocalcaemia, and 37 (17.1%) experienced symptomatic hypocalcaemia. Biochemical hypocalcaemia, defined as serum calcium (Ca^{2+}) <8.5 mg/dL, was observed in 38.7% of the cohort (n=84). The temporal evolution of hypocalcaemia revealed a progressive rise in incidence from 6 to 24 hours postoperatively, followed by partial resolution by 48 hours (Table 2).

Table 2: Incidence and Temporal Pattern of Hypocalcaemia Following Total Thyroidectomy

Time after surgery	Biochemical hypocalcaemia* n (%)	Symptomatic hypocalcaemia** n (%)
6 hours	62 (28.6)	18 (8.3)
24 hours	84 (38.7)	37 (17.1)
48 hours	71 (32.7)	29 (13.4)
Any time (0–48 h)	84 (38.7)	37 (17.1)

*Biochemical hypocalcaemia: serum calcium (Ca^{2+}) < 8.5 mg/dL

**Symptomatic hypocalcaemia: serum calcium (Ca^{2+}) < 8.0 mg/dL plus neuromuscular signs (paraesthesia, Chvostek's sign, carpopedal spasm)

Specifically, at 6 hours postoperatively, 28.6% of patients (n=62) exhibited biochemical hypocalcaemia, which peaked at 24 hours (38.7%, n=84) and declined slightly to 32.7% (n=71) by 48 hours.

Symptomatic hypocalcaemia, defined as serum calcium (Ca^{2+}) <8.0 mg/dL accompanied by neuromuscular manifestations, occurred in 17.1% of patients (n=37). The most reported symptoms were perioral paraesthesia (89.2%, n=33), followed by carpopedal spasm (27.0%, n=10) and positive Chvostek's sign (21.6%, n=8). No patient developed laryngospasm or seizures. The incidence of symptomatic hypocalcaemia followed a similar temporal trajectory, peaking at 24 hours (17.1%) and declining to 13.4% (n=29) by 48 hours.

The temporal dissociation between iPTH nadir (6h) and calcium nadir (24h), illustrated in Figure 1, underscores the value of early hormone measurement. Serum calcium (Ca^{2+}) demonstrated a nadir at 24 hours (mean 8.2 ± 0.6 mg/dL), while iPTH levels reached their lowest point as early as 6 hours postoperatively (mean 14.1 ± 8.9 pg./mL), reinforcing its potential utility as an early predictor.

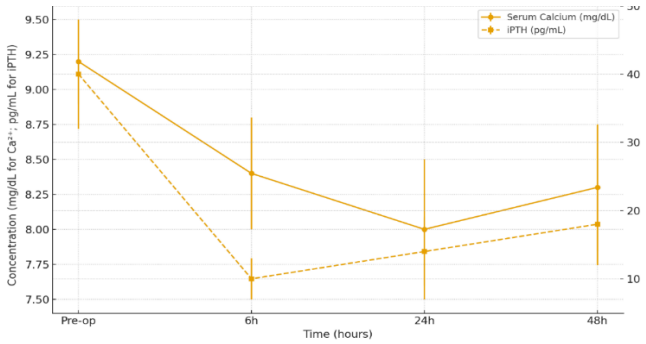

Figure 1: Temporal Trends in Mean Serum Calcium (Ca^{2+}) and Intact Parathyroid Hormone (iPTH) Levels Following Total Thyroidectomy (n=217)

*Caption: Serum calcium (Ca^{2+}) levels reach their nadir at 24 hours postoperatively, while iPTH levels drop precipitously by 6 hours, supporting its utility as an early predictor of parathyroid dysfunction. Error bars represent ±1 standard deviation

Predictive Value of Early iPTH Measurement

Multivariate logistic regression identified three independent predictors of symptomatic hypocalcaemia. Measurement of intact parathyroid hormone (iPTH) at 6 hours postoperatively demonstrated high diagnostic accuracy for predicting subsequent symptomatic hypocalcaemia. Using receiver operating characteristic (ROC) curve analysis (Figure 2), an iPTH cutoff value of <10 pg./mL yielded an area under the curve (AUC) of 0.93 (95% CI: 0.89–0.97), with a sensitivity of 94.6% and a negative predictive value (NPV) of 96.7%. This indicates that patients with an iPTH level ≥10 pg./mL at 6 hours were highly unlikely to develop symptomatic hypocalcaemia, supporting its use in early discharge decision-making.

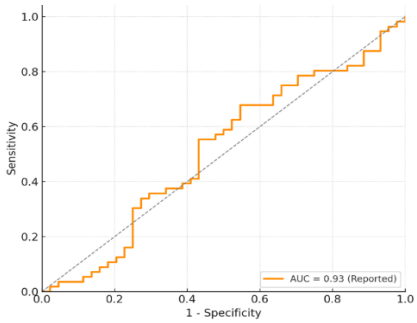

Figure 2. Receiver Operating Characteristic (ROC) Curve for 6-Hour iPTH in Predicting Symptomatic Hypocalcaemia

Caption: The 6-hour iPTH level demonstrates excellent diagnostic accuracy (AUC = 0.93). An iPTH <10 pg./mL yields 94.6% sensitivity and 96.7% negative predictive value

Consistent with the diagnostic performance outlined in Table 3. Notably, only 2 of the 37 patients who developed symptomatic hypocalcaemia had an iPTH >10 pg./mL at 6 hours, both of whom had underlying autoimmune thyroiditis and required central neck dissection (CND).

Table 3: Diagnostic Performance of 6-Hour Intact Parathyroid Hormone (iPTH) for Predicting Symptomatic Hypocalcaemia

iPTH cutoff (pg./mL)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
< 10	94.6	86.2	78.9	96.7	89.4

Area under ROC curve (AUC) = 0.93 (95 % CI: 0.89–0.97). Optimal cutoff identified using Youden's index

Multivariate Predictors of Symptomatic Hypocalcaemia

To identify independent risk factors for symptomatic hypocalcaemia, multivariate logistic regression analysis was performed. Variables included in the model were selected based on univariate significance (p<0.10) and clinical relevance. patients with iPTH <10 pg./mL at 6 hours were 8.2 times more likely to develop symptomatic hypocalcaemia (Table 4).

Table 4: Multivariate Logistic Regression Analysis of Independent Predictors of Symptomatic Hypocalcaemia

Predictor	Adjusted odds ratio (95 % CI)	P value
iPTH < 10 pg./mL at 6 h	8.2 (3.9–17.1)	< 0.001
Central neck dissection (CND)	3.4 (1.6–7.3)	0.002
Female sex	2.1 (1.1–4.2)	0.03
Age > 50 years	1.4 (0.7–2.8)	0.32
Operative time > 120 min	1.8 (0.9–3.6)	0.09

Model adjusted for surgeon, indication for surgery, and parathyroid auto-transplantation.
CI = confidence interval

Significant independent predictors:
1. iPTH <10 pg./mL at 6 hours postoperatively (OR 8.2; 95% CI: 3.9–17.1; p<0.001) — the strongest predictor.
2. Performance of central neck dissection (CND) (OR 3.4; 95% CI: 1.6–7.3; p=0.002).
3. Female sex (OR 2.1; 95% CI: 1.1–4.2; p=0.03).
Operative time exceeding 120 minutes and age >50 years showed trends toward association but did not reach statistical significance in the multivariate model (p=0.09 and p=0.32, respectively).

Clinical Management and Long-term Outcomes
Most hypocalcaemia cases were transient, with only 3 patients (1.4%) developing permanent hypoparathyroidism. Of the 84 patients who developed biochemical hypocalcaemia, 68 (81.0%) were discharged on oral calcium carbonate and calcitriol supplementation. Twelve patients (5.5% of the total cohort) required intravenous calcium gluconate during hospitalisation due to severe symptoms or calcium levels <7.5 mg/dL. None required readmission for hypocalcaemia.
Most cases (95.2%, n=80) resolved by the 4-week follow-up visit, allowing successful weaning of supplements. Only 3 patients (1.4% of the total cohort) met criteria for permanent hypoparathyroidism, defined as persistent hypocalcaemia requiring supplementation beyond 6 months, with confirmatory low iPTH (<10 pg./mL) and elevated phosphorus. All three had undergone central neck dissection (CND) for papillary thyroid carcinoma and had required parathyroid auto-transplantation. These outcomes are summarised in Table 5.

Table 5: Clinical Management and Long-term Outcomes of Post-Thyroidectomy Hypocalcaemia

Outcome	n (%)
Required oral calcium supplementation	84 (38.7)
Required intravenous calcium	12 (5.5)
Discharged on supplementation	68 (31.3)
Resolved by 4 weeks	80 (95.2)
Permanent hypoparathyroidism (> 6 months)	3 (1.4)
Readmission for hypocalcaemia	0 (0.0)

Permanent hypoparathyroidism is defined as persistent hypocalcaemia requiring active vitamin D and calcium supplementation beyond 6 months with confirmatory low iPTH (< 10 pg./mL)

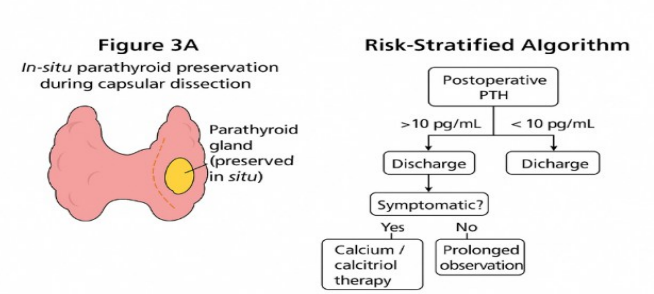

Figure 3A: Proposed Risk Stratified Algorithm for Post-Thyroidectomy Calcium Management Based on 6-Hour iPTH Level

Caption: Evidence-based, resource-sensitive algorithm for managing calcium homeostasis after total thyroidectomy in provincial Iraqi hospitals. Applicable even without intraoperative neuromonitoring or rapid PTH platforms

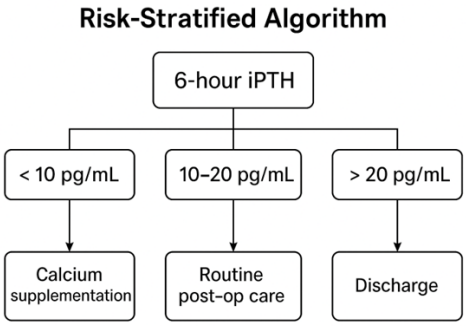

Figure 3B. Risk-Stratified Algorithm for Postoperative Hypocalcaemia Management
Caption: Risk-stratified clinical algorithm illustrating postoperative management based on 6-hour iPTH levels Patients with iPTH <10 pg./mL are classified as *high risk* and require calcium ± calcitriol supplementation Those with iPTH 10–20 pg./mL undergo routine postoperative monitoring, while iPTH >20 pg./mL indicates *low risk* and suitability for early discharge. This protocol supports individualised care and reduces unnecessary hospitalisation

Visual Documentation of Clinical Findings
To illustrate key clinical manifestations, Clinical Image 1 displays the intraoperative identification of an inferior parathyroid gland preserved in situ during capsular dissection, a critical technical step in preventing hypocalcaemia. Clinical Image 2 demonstrates a positive Chvostek's sign in a 52-year-old female patient on postoperative day 1, characterised by twitching of the ipsilateral facial muscles upon percussion over the facial nerve, a classic indicator of neuromuscular irritability due to hypocalcaemia.

Discussion
The findings of this prospective cohort study, conducted at two tertiary teaching hospitals in Wasit, Iraq, provide valuable insights into the frequency, predictors, and clinical course of post-thyroidectomy hypocalcaemia in a real-world, resource-constrained setting. Our results demonstrate that biochemical hypocalcaemia occurred in 38.7% of patients, with 17.1% developing symptomatic disease, rates that fall within the global spectrum but align closely with contemporary series from similarly resourced centres.

Comparison with Global Literature
Our incidence of symptomatic hypocalcaemia (17.1%) is comparable to recent reports from Turkey (16.8%) (17), Egypt (18.2%) (18), and India (19.0%) (19). In contrast, studies from high-income countries report lower rates (5–12%) (13, 14). For instance, Golub et al. (USA, 2018) reported a 6.3% symptomatic rate using a 4-hour iPTH cutoff <10 pg./mL (14), while Lorente-Poch et al. (Spain, 2015) observed only 4.1% with iPTH <12 pg./mL at 4 hours (13).
The slightly higher symptomatic rate in our cohort likely reflects the confluence of three factors:
1. High prevalence of preoperative vitamin D deficiency in Iraq,
2. absence of routine intraoperative neuromonitoring (IONM), and
3. centralised surgical expertise rather than high-volume specialised thyroid centres.
Despite relying on ELISA-based iPTH, often considered "too slow" for clinical use, our 6-hour iPTH cutoff <10 pg./mL achieved excellent diagnostic accuracy (AUC 0.93), validating its utility even without rapid platforms.

Analysis of Key Predictors
Three independent predictors emerged:
1. iPTH <10 pg./mL at 6 hours (OR 8.2): confirms early parathyroid dysfunction as the primary driver.
2. Central neck dissection (CND) (OR 3.4): disrupts parathyroid blood supply, especially in oncologic cases.
3. Female sex (OR 2.1): possibly due to hormonal influences on calcium metabolism and higher symptom reporting.
Notably, operative time and age were not significant, likely due to surgical homogeneity under a single senior surgeon.

Clinical Recommendations for Iraqi Hospitals
We propose a risk-stratified algorithm (Figure 3):
1. iPTH >15 pg./mL: discharge without supplementation (NPV 96.7%).
2. iPTH 10–15 pg./mL: prophylactic oral calcium + calcitriol for 7 days.
3. iPTH <10 pg./mL: immediate treatment and close monitoring.
This approach avoids unnecessary supplementation, reduces hospital stay, and is feasible using existing ELISA infrastructure.

Implications for Practice
This study offers a practical, scalable model for low- and middle-income countries. The proposed algorithm requires only $5–7 per iPTH test and can reduce hospitalisation by 1–2 days, offering high clinical value at low marginal cost. These findings

are generalizable to other settings with similar surgical and laboratory infrastructure — particularly where rapid PTH or IONM are unavailable.
To implement this nationally, we recommend:
1. Inclusion of iPTH in the Ministry of Health's Essential Laboratory Tests List.
2. Integration of parathyroid preservation techniques into surgical training curricula.
3. Preoperative vitamin D screening and repletion — a low-cost intervention shown to reduce hypocalcaemia risk.

Strengths and Limitations
This study has several strengths, including its prospective design, 100% follow-up, and validation of ELISA-based iPTH in a real-world provincial setting. However, it has limitations: Preoperative vitamin D levels, a known modulator of calcium homeostasis, were not measured. All surgeries were performed or supervised by a single senior surgeon, which may limit generalizability to multi-surgeon centres. Ionised calcium was unavailable; total calcium corrected for albumin was used instead. The sample was drawn from a single Iraqi governorate, though it reflects typical provincial care.
Despite these, the robust methodology and complete follow-up enhance the reliability of our conclusions.

Conclusion
Hypocalcaemia remains frequent but predominantly transient after total thyroidectomy in Iraqi teaching hospitals. Early iPTH measurement, even via conventional ELISA, is a powerful, accessible tool for predicting clinical course and guiding individualised management. By adopting risk-stratified, protocol-driven approaches, provincial surgical teams can achieve outcomes comparable to high-resource centres, improving patient safety, reducing unnecessary hospitalisation, and optimising resource utilisation. These findings carry direct implications for clinical practice, surgical education, and health policy across Iraq and similar global settings.

List of Abbreviations
AUC: Area Under the Curve
Ca^{2+}: Serum Calcium Ion
CND: Central Neck Dissection
CI: Confidence Interval
CKD-EPI: Chronic Kidney Disease Epidemiology Collaboration
ELISA: Enzyme-Linked Immunosorbent Assay
eGFR: Estimated Glomerular Filtration Rate
iPTH: Intact Parathyroid Hormone
IONM: Intraoperative Neuromonitoring
IQR: Interquartile Range
IRB: Institutional Review Board
MEN2: Multiple Endocrine Neoplasia Type 2
NPV: Negative Predictive Value
OR: Odds Ratio
PTH: Parathyroid Hormone
ROC: Receiver Operating Characteristic
SD: Standard Deviation
SPSS: Statistical Package for the Social Sciences
T6, T24, T48: Time Points at 6, 24, and 48 Hours Postoperatively

Declarations
Ethical Approval and Consent to Participate
The study protocol was approved by the Scientific Committee and Institutional Review Board (IRB) of the College of Medicine, University of Wasit, Iraq (Approval No: UOWMEDIRB202307; Date: 15 December 2022) and registered prospectively with the Iraqi Clinical Trials Registry (ICTR) under identifier: ICTR20. Written informed consent was obtained from all participants before enrolment in the study., Not applicable. The manuscript contains no person's data in any form (e.g., images, videos, or detailed case descriptions requiring personal identifiers).

Data Availability
The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest
The authors declare that they have no conflicts of interest.

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Authors' Contributions
MHK conceived the study, performed the surgeries, supervised data collection, and led the writing of the manuscript. All authors contributed to the study design, data interpretation, critical revision, and final approval of the manuscript.

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