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Review Article

Role of Procalcitonin Versus C-Reactive Protein in Guiding Antibiotic Therapy for Surgical Infections: A Structured Narrative Review

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ABSTRACT

Background: Surgical and postoperative infections require timely antimicrobial treatment, but physiological inflammation after surgery can resemble bacterial infection and complicate decisions regarding antibiotic duration. Procalcitonin and C-reactive protein are commonly evaluated as adjunctive biomarkers, although their comparative clinical roles remain uncertain. Objective: To critically compare the biological characteristics, postoperative kinetics, diagnostic utility, and antimicrobial-stewardship applications of PCT and CRP in surgical and postoperative infections through a structured narrative review. Methods: A focused review of peer-reviewed biomedical literature was undertaken using terms related to PCT, CRP, surgical infection, postoperative infection, surgical-site infection, antibiotic duration, and antimicrobial stewardship. Foundational biomarker studies, diagnostic investigations, randomized trials, systematic reviews, meta-analyses, and clinically relevant cohort studies were synthesized thematically. Evidence was interpreted according to study design, population, directness of surgical relevance, biomarker timing, and reported clinical application. Results: CRP was consistently identified as a sensitive, widely available marker of inflammatory activity, but its frequent elevation after uncomplicated surgery limited its specificity for bacterial infection. PCT demonstrated comparatively greater association with systemic bacterial activity and generally declined more rapidly after effective infection control. Randomized evidence from heterogeneous critically ill populations supported PCT-guided strategies for reducing antibiotic exposure without compromising clinical safety, although direct evidence from exclusively surgical populations remained limited. Neither biomarker reliably distinguished all postoperative infections from sterile inflammation, and no universal threshold was supported across surgical procedures. Conclusion: PCT has greater potential than CRP as an adjunct to antibiotic-discontinuation decisions, whereas CRP remains useful for monitoring general inflammatory trends. Both biomarkers should be interpreted serially and integrated with clinical assessment, microbiological findings, imaging, and confirmation of adequate source control. Keywords: Procalcitonin; C-Reactive Protein; Surgical Wound Infection; Postoperative Complications; Anti-Bacterial Agents; Antimicrobial Stewardship; Biomarkers; Intra-Abdominal Infections

INTRODUCTION

Postoperative and surgery-associated infections remain important causes of delayed recovery, prolonged hospitalization, repeated interventions, and increased antimicrobial exposure. These infections encompass surgical-site infections, postoperative intra-abdominal infections, procedure-related sepsis, and infections occurring in critically ill surgical patients. Their management requires timely antimicrobial therapy, appropriate microbiological investigation, and effective surgical source control. Determining the appropriate duration of antibiotic treatment, however, remains difficult. Premature discontinuation may contribute to persistent or recurrent infection, whereas unnecessarily prolonged

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therapy increases the risk of adverse drug effects, Clostridioides difficile infection, antimicrobial resistance, and avoidable healthcare expenditure (1-3).

Clinical assessment after surgery is complicated by the physiological inflammatory response to tissue injury. Fever, leukocytosis, tachycardia, and elevated inflammatory markers may occur following major surgery even in the absence of bacterial infection. Conversely, postoperative infection may initially produce subtle or nonspecific manifestations. Conventional clinical and laboratory parameters therefore have limited ability to distinguish expected postoperative inflammation from an uncontrolled bacterial process. This diagnostic uncertainty frequently results in empirical initiation or continuation of antibiotics while clinicians await microbiological, radiological, or operative confirmation (4-5).

C-reactive protein (CRP) is an acute-phase reactant synthesized predominantly by hepatocytes in response to inflammatory cytokines, particularly interleukin-6. Its wide availability, relatively low cost, and sensitivity to inflammatory activity have made it one of the most frequently monitored biomarkers in postoperative practice. CRP concentrations typically increase after tissue trauma and may remain elevated for several days following uncomplicated surgery. Consequently, although serial CRP trends may assist in monitoring the postoperative inflammatory response, an isolated elevation has limited specificity for bacterial infection and cannot independently determine whether antibiotic therapy should be initiated, continued, or discontinued (6-7).

Procalcitonin (PCT), the precursor of calcitonin, is normally present at very low circulating concentrations. During systemic bacterial infection, proinflammatory mediators and bacterial products stimulate extrathyroidal PCT production in multiple tissues, resulting in a measurable increase within several hours. PCT concentrations generally decline following effective control of bacterial infection, giving the biomarker potential value for serial assessment and antibiotic-discontinuation decisions (2,3). Nevertheless, PCT is not exclusively elevated in infection. Major surgery, severe trauma, burns, circulatory shock, and other forms of systemic inflammation may also increase its concentration, particularly during the early postoperative period.

Evidence suggests that PCT has moderate diagnostic accuracy for bacterial sepsis when interpreted alongside clinical findings rather than as an independent diagnostic test (4). Randomized trials in heterogeneous critically ill populations have further demonstrated that PCT-guided algorithms can reduce antibiotic exposure without a corresponding increase in mortality or treatment failure (5,6). These findings have strengthened interest in PCT as an antimicrobial-stewardship biomarker. Their direct applicability to all surgical infections remains uncertain, however, because many intervention studies have enrolled mixed medical and surgical intensive-care populations rather than patients with clearly defined postoperative or surgical-site infections (8).

Evidence concerning CRP and PCT in surgical practice is therefore heterogeneous. Studies differ in surgical population, type and magnitude of procedure, timing of biomarker measurement, diagnostic reference standard, PCT threshold, definition of clinical improvement, adequacy of source control, and criteria for antibiotic discontinuation. Diagnostic studies, mechanistic investigations, randomized stewardship trials, and systematic reviews also address different clinical questions and cannot be interpreted as equivalent forms of evidence. A focused synthesis is needed to clarify the complementary roles of these biomarkers while distinguishing direct evidence from surgical populations from indirect evidence derived from broader critical-care settings.

Accordingly, this structured narrative review critically compares the biological characteristics, postoperative kinetics, diagnostic utility, and antimicrobial-stewardship applications of PCT and CRP in surgical and postoperative infections. Particular emphasis is placed on their ability to distinguish bacterial infection from sterile postoperative inflammation, their potential contribution to antibiotic-discontinuation decisions, and the limitations that prevent either biomarker from replacing clinical assessment, microbiological testing, imaging, and surgical source control.

MATERIAL AND METHODS

This article was designed as a structured narrative review because the objective was to integrate biological, diagnostic, prognostic, and antimicrobial-stewardship evidence derived from heterogeneous clinical settings rather than to calculate a pooled treatment or diagnostic effect. The narrative approach allowed evidence from surgical cohorts, postoperative populations, mixed intensive-care populations, diagnostic-accuracy studies, randomized stewardship trials, systematic reviews, and foundational biomarker research to be examined within a common clinically oriented framework.

A focused search of peer-reviewed biomedical literature was undertaken using combinations of the terms “procalcitonin,” “C-reactive protein,” “surgical infection,” “postoperative infection,” “surgical-site infection,” “intra-abdominal infection,” “postoperative sepsis,” “antibiotic duration,” “antibiotic discontinuation,” and “antimicrobial stewardship.” Reference lists of relevant reviews and influential primary studies were also examined to identify additional publications directly related to biomarker interpretation and antibiotic decision-making in surgical or critically ill populations.

Studies were considered relevant when they evaluated PCT, CRP, or both biomarkers in patients undergoing surgery, receiving postoperative care, or being treated for a surgery-associated infection. Evidence addressing diagnostic discrimination, infectious complications, clinical recovery, treatment failure, antibiotic initiation, antibiotic duration, antibiotic discontinuation, or antimicrobial exposure was prioritized. Randomized controlled trials, systematic reviews, meta-analyses, diagnostic-accuracy studies, prospective or retrospective cohort studies, and foundational studies describing biomarker biology and kinetics were considered. Case reports, very small uncontrolled series, reports focused exclusively on rare adverse events, and studies without clinically relevant infection or antibiotic-related outcomes were not prioritized.

Evidence from mixed medical and surgical intensive-care populations was retained when it directly informed the use of PCT or CRP for antibiotic stewardship or infection assessment. Such evidence was interpreted as indirect when surgical patients were not separately analyzed. Studies conducted entirely in non-surgical populations were used only when they provided relevant biological, diagnostic, or stewardship context and were not presented as direct evidence for postoperative surgical practice.

The literature was organized according to predefined clinical themes: the biological basis and postoperative kinetics of PCT and CRP; differentiation of sterile postoperative inflammation from bacterial infection; diagnostic and prognostic performance in surgical patients; biomarker-guided antibiotic discontinuation; applications in surgical-site and intra-abdominal infections; combined interpretation of PCT and CRP; and integration of biomarker findings with clinical assessment, microbiology, imaging, and source-control evaluation. During synthesis, particular attention was given to study design, patient population, clinical setting, timing of biomarker measurement, biomarker thresholds or trends, antibiotic-related outcomes, and the directness of each study’s relevance to surgical practice.

The strength of the evidence was interpreted according to study design and clinical applicability. Randomized trials were given greater weight when evaluating antibiotic-discontinuation strategies, whereas diagnostic-accuracy studies and postoperative cohort studies were used primarily to assess infection discrimination and biomarker trajectories. Findings from systematic reviews and meta-analyses were considered in relation to the populations and studies they included. Biological plausibility and expert interpretation were used to contextualize, but not replace, clinical outcome evidence.

No quantitative pooling was undertaken because of substantial heterogeneity in patient populations, surgical procedures, infection definitions, biomarker thresholds, sampling intervals, and clinical outcomes. The synthesis therefore emphasizes the direction, consistency, clinical relevance, and limitations of the available evidence rather than producing a summary effect estimate. Because the

literature search and selection process were focused rather than exhaustive and did not involve formal dual independent screening or standardized risk-of-bias assessment, the review may be susceptible to selection and interpretive bias. Conclusions were consequently framed cautiously, with explicit distinction between direct surgical evidence and findings extrapolated from mixed or non-surgical populations.

RESULTS

The literature relevant to the comparative use of procalcitonin and C-reactive protein comprised foundational biomarker studies, diagnostic-accuracy investigations, postoperative observational studies, randomized antibiotic-stewardship trials, and systematic reviews conducted across surgical, mixed intensive-care, and non-surgical populations. The evidence was heterogeneous with respect to operative setting, infection definition, biomarker threshold, timing of measurement, and clinical outcome. Three principal themes emerged: differences in the biological and postoperative kinetics of PCT and CRP, their comparative value in distinguishing bacterial infection from sterile inflammation, and their potential use as adjuncts to antibiotic-discontinuation decisions.

CRP and PCT respond to inflammation through different biological pathways and therefore provide different forms of clinical information. CRP is synthesized predominantly in the liver following stimulation by inflammatory cytokines, particularly interleukin-6. Its concentration increases in response to bacterial infection, non-bacterial inflammation, tissue trauma, autoimmune activity, and surgery. This broad responsiveness makes CRP a sensitive indicator of inflammatory activity but limits its specificity for bacterial infection (1).

PCT is normally present at very low circulating concentrations. During systemic bacterial infection, bacterial endotoxins and inflammatory mediators stimulate widespread extrathyroidal production, producing a measurable increase within several hours (2,3). PCT concentrations generally decline more rapidly than CRP following effective control of bacterial infection. This kinetic pattern provides a biological rationale for using serial PCT measurements to support decisions concerning antibiotic discontinuation. Nevertheless, major surgery, trauma, burns, shock, and severe systemic inflammation may also increase PCT, particularly during the early postoperative period (3).

The timing of measurement was consistently important for both biomarkers. An early postoperative increase in CRP is expected following substantial tissue injury and may persist during otherwise uncomplicated recovery. Consequently, a single elevated postoperative CRP value has limited diagnostic specificity. Persistent elevation, failure to decline, or a secondary increase may be more clinically informative than an isolated measurement, although these patterns remain insufficient to confirm infection independently.

PCT may also rise transiently after major surgery in the absence of infection. However, uncomplicated postoperative elevations generally decline earlier than CRP elevations. Failure of PCT to decrease, or a secondary increase accompanied by clinical deterioration, may increase suspicion of an ongoing bacterial process. The magnitude and interpretation of this response vary according to the type and extent of surgery, the presence of organ dysfunction, the timing of sampling, and the effectiveness of source control.

The principal diagnostic challenge after surgery is not the identification of inflammation itself but the differentiation of an expected postoperative inflammatory response from persistent or newly developing bacterial infection. The available evidence suggested that neither PCT nor CRP was sufficiently accurate to function as an independent diagnostic test.

A systematic review and meta-analysis evaluating PCT for the diagnosis of sepsis found moderate diagnostic accuracy and emphasized that PCT should be interpreted as an adjunct to clinical assessment rather than as a replacement for it (4). Although this evidence was not limited to surgical populations,

it supported the comparatively closer association of PCT with systemic bacterial infection. The diagnostic performance varied across settings and thresholds, indicating that a universal concentration cannot reliably classify every patient.

Evidence from major abdominal surgery similarly indicated that postoperative biomarker interpretation depends on temporal patterns rather than isolated values. A systematic review and meta-analysis of PCT and CRP following major abdominal surgery found that postoperative elevations were associated with infectious complications, with PCT showing potential value for earlier identification of persistent bacterial inflammation (7). However, substantial variation in operative procedures, sampling intervals, infection definitions, and biomarker thresholds limited direct comparison between studies.

Table 1. Comparative Biological and Clinical Characteristics of Procalcitonin and C-Reactive Protein

Characteristic	Procalcitonin	C-Reactive Protein
Principal biological stimulus	Systemic bacterial infection and severe systemic inflammation	Broad inflammatory cytokine response
Main production pattern	Extrathyroidal production by multiple tissues during bacterial inflammation	Predominantly hepatic synthesis
Approximate initial increase after stimulation	Approximately 2–6 hours	Approximately 6–12 hours
Specificity for bacterial infection	Comparatively higher, but not absolute	Lower because of elevation in infectious and non-infectious inflammation
Response to surgical trauma	May increase after major surgery	Frequently and substantially increases after surgery
Decline after infection control	Generally more rapid	Usually slower and may remain elevated during clinical recovery
Value of isolated measurement	Limited; requires clinical and temporal interpretation	Limited because postoperative elevation is common
Value of serial measurement	May support assessment of bacterial activity and antibiotic discontinuation	Useful for monitoring the direction of the inflammatory response
Evidence for antibiotic-discontinuation guidance	Comparatively stronger	Limited
Availability	Variable between institutions	Widely available
Relative cost	Usually higher	Usually lower
Principal limitation	Can increase with major non-infectious systemic insults	Poor specificity for bacterial infection

CRP remained useful as a broadly available marker of postoperative inflammatory activity. A declining CRP trend generally corresponded with resolution of the inflammatory response, whereas persistent elevation or a secondary rise could identify patients requiring further clinical evaluation. Its diagnostic value was nevertheless constrained by the marked increase that commonly follows uncomplicated surgery. Elevated CRP therefore indicated ongoing inflammation but did not establish whether the cause was bacterial infection, tissue injury, anastomotic leakage, ischemia, or another postoperative complication.

The comparative utility of PCT and CRP also varied according to the clinical condition being assessed. In suspected acute appendicitis, both biomarkers were evaluated as adjuncts to clinical diagnosis, but neither was sufficient to replace clinical examination or imaging (11). This evidence was directly relevant to an acute surgical condition but did not necessarily generalize to postoperative infection or antibiotic-discontinuation decisions.

Across the diagnostic evidence, serial measurements appeared more informative than isolated concentrations. A declining PCT concentration supported a reduction in systemic bacterial activity, whereas persistent or increasing concentrations raised concern for inadequate infection control. Similarly, serial CRP trends could assist in identifying deviation from the expected postoperative course. In both cases, interpretation remained dependent on the clinical trajectory, procedure type, microbiological findings, imaging results, and adequacy of surgical source control.

The strongest interventional evidence concerned the use of PCT to support antibiotic-discontinuation decisions in critically ill patients. In the PRORATA multicentre randomized controlled trial, a PCT-guided strategy reduced antibiotic exposure compared with standard care without increasing mortality or treatment failure (5). The trial provided important evidence that serial PCT measurements could be incorporated into structured antibiotic algorithms. However, the population included heterogeneous critically ill patients and was not restricted to postoperative surgical infections.

A subsequent randomized controlled trial by de Jong et al. similarly found that PCT-guided antibiotic management reduced the duration of treatment in critically ill patients without compromising clinical safety (6). The findings reinforced the potential value of PCT as a discontinuation aid, particularly when the patient was clinically improving and no uncontrolled infectious source remained. As with PRORATA, direct applicability to all surgical-site, intra-abdominal, and procedure-related infections was limited by the mixed intensive-care population.

A meta-analysis of PCT-guided antibiotic treatment in critically ill adults provided broader support for reductions in antibiotic exposure associated with PCT-based algorithms (8). Nevertheless, variation in algorithm thresholds, definitions of adequate PCT decline, infection types, and clinical settings complicated the identification of a single optimal protocol. Reviews of PCT-guided stewardship have therefore emphasized that biomarker algorithms should complement clinical reassessment rather than compel antibiotic discontinuation irrespective of the patient's condition (9).

Evidence supporting CRP-guided antibiotic discontinuation was substantially less developed. CRP concentrations may remain elevated despite effective treatment and clinical improvement because their decline is slower and because persistent tissue inflammation may continue after bacterial control. Requiring CRP normalization before stopping antibiotics could therefore prolong therapy unnecessarily. CRP trends may still contribute to clinical monitoring, but the reviewed evidence did not support CRP as an independent stopping rule.

Evidence from acute respiratory infections also showed that PCT-guided algorithms could reduce antibiotic initiation or duration in non-surgical settings (10). This supported the general antimicrobial-stewardship concept but represented indirect evidence for surgical practice. Extrapolation was particularly limited in patients with an undrained abscess, anastomotic leak, infected prosthetic material, necrotic tissue, or another condition requiring procedural source control.

Direct evidence from exclusively surgical populations was less extensive than evidence from mixed intensive-care cohorts. Postoperative studies focused primarily on the diagnostic or prognostic association between biomarker trends and infectious complications rather than on randomized comparisons of biomarker-guided antibiotic duration.

Following major abdominal surgery, PCT and CRP were both associated with postoperative infectious complications, but their usefulness depended on the day of measurement and the selected threshold (7). PCT appeared biologically advantageous when the clinical question concerned persistent bacterial activity, whereas CRP was more suitable for observing the overall inflammatory trajectory. Neither marker reliably differentiated every infectious complication from non-infectious postoperative morbidity.

In surgical-site infection, the utility of biomarkers was influenced by whether infection remained localized or had produced a systemic response. CRP could increase in response to both superficial and deep inflammation but lacked the specificity needed to define the cause. PCT was potentially more informative when infection was associated with systemic bacterial activity, although a low concentration could not independently exclude a localized infection. Clinical examination of the wound, microbiological sampling, imaging, and procedural evaluation therefore remained essential.

In postoperative intra-abdominal infection, biomarker findings were clinically meaningful only when interpreted in relation to source control. A declining PCT concentration after drainage, debridement, repair, or other effective intervention could support antibiotic de-escalation in a clinically improving patient. Conversely, persistent biomarker elevation could indicate ongoing inflammation but could not identify whether the underlying cause was an undrained collection, an anastomotic complication, tissue ischemia, or another postoperative process. Imaging and surgical reassessment remained necessary when recovery did not follow the expected course.

The evidence did not support the use of a single PCT or CRP threshold across all surgical procedures. Major abdominal, cardiothoracic, trauma, transplant, and other complex operations produce different baseline inflammatory responses. Differences in renal function, illness severity, immunosuppression, and timing of measurement further modified biomarker interpretation. Serial change within the individual patient was therefore more clinically meaningful than reliance on a universal isolated cut-off.

Table 2. Principal Evidence Informing the Use of Procalcitonin and C-Reactive Protein

Study	Design and population	Biomarker focus	Principal contribution to the synthesis	Relevance to surgical practice	Important limitation
Pepys and Hirschfield (1)	Critical review of CRP biology and clinical interpretation	CRP	Established CRP as a sensitive but non-specific marker of systemic inflammation	Biological and interpretive background	Not specific to surgical infection
Assicot et al. (2)	Foundational clinical investigation in sepsis and infection	PCT	Demonstrated marked PCT elevation in severe bacterial infection	Supports biological rationale for bacterial specificity	Early study; not focused on postoperative antibiotic decisions
Meisner (3)	Clinical update on PCT measurement	PCT	Described kinetics, interpretation, and non-infectious causes of elevation	Relevant to postoperative interpretation	Narrative clinical overview rather than surgical trial
Wacker et al. (4)	Systematic review and meta-analysis of sepsis diagnosis	PCT	Reported moderate diagnostic accuracy and emphasized adjunctive use	Supports infection assessment in critically ill surgical patients	Population not restricted to surgical patients
Bouadma et al. (5)	Multicentre randomized controlled trial in intensive-care patients	PCT-guided antibiotic strategy	Reduced antibiotic exposure without increased mortality or treatment failure	Important indirect evidence for postoperative ICU stewardship	Mixed medical and surgical population
de Jong et al. (6)	Randomized controlled trial in critically ill patients	PCT-guided antibiotic duration	Shortened antibiotic treatment without compromising safety	Supports discontinuation decisions in clinically improving patients	Not limited to defined surgical infections
Huang et al. (7)	Systematic review and meta-analysis after major abdominal surgery	PCT and CRP	Evaluated diagnostic performance for postoperative infection	Directly relevant to postoperative abdominal surgery	Heterogeneous procedures, timing, thresholds, and infection definitions
Liu et al. (8)	Meta-analysis in critically ill adults	PCT-guided antibiotic therapy	Supported reduced antimicrobial exposure with PCT-based algorithms	Applicable to surgical critical care with caution	Considerable clinical and protocol heterogeneity
Sager et al. (9)	Review of PCT diagnosis and stewardship	PCT	Synthesized diagnostic and stewardship applications	Provides framework for adjunctive clinical use	Not a surgical-specific evidence synthesis
Schuetz et al. (10)	Systematic review of acute respiratory infections	PCT-guided antibiotic use	Supported reduction of unnecessary antibiotic exposure	Supports general stewardship principle	Indirect non-surgical evidence
Gans et al. (11)	Diagnostic study/review in suspected acute appendicitis	PCT and CRP	Evaluated biomarkers as adjuncts in an acute surgical condition	Direct relevance to appendicitis assessment	Does not address postoperative infection or treatment duration

The evidence did not indicate that one biomarker should universally replace the other. CRP and PCT reflected overlapping but non-identical aspects of the inflammatory response. CRP was more accessible and useful for identifying the direction of postoperative inflammation, whereas PCT was more closely associated with systemic bacterial activity and had stronger evidence for supporting antibiotic-discontinuation strategies.

Concordant biomarker and clinical trends were potentially more informative than either marker alone. In a clinically improving patient with effective source control, falling PCT and CRP concentrations supported resolution of infection and inflammation. A rapid reduction in PCT accompanied by a slower decline in CRP was also biologically plausible and did not necessarily indicate treatment failure. Conversely, persistent or increasing PCT accompanied by clinical deterioration increased concern for continuing bacterial infection, while persistent CRP elevation alone remained less specific.

Discordant results required contextual interpretation. A low or declining PCT concentration did not exclude a localized surgical-site or intra-abdominal infection. Similarly, a persistently elevated CRP concentration did not necessarily justify continued antibiotic therapy when the patient was clinically stable, microbiological findings were reassuring, and source control was adequate. Biomarker values were therefore most useful when they altered the probability of infection in conjunction with other clinical information rather than when used as absolute treatment commands.

Across the reviewed evidence, biomarker-supported management was most defensible when incorporated into a structured reassessment process. This process included evaluation of the patient's temperature, haemodynamic status, organ function, leukocyte count, operative findings, microbiological results, imaging, wound appearance, and response to source-control procedures.

PCT had the strongest evidence for supporting antibiotic discontinuation when concentrations declined and the patient demonstrated clinical improvement. This role was more robustly supported than the use of PCT to initiate antibiotics or independently diagnose postoperative infection. CRP remained useful for monitoring broad inflammatory trends and detecting deviation from expected recovery but was not supported as an independent determinant of antibiotic duration.

Table 3. Potential Adjunctive Applications of PCT and CRP in Surgical Patients

Clinical situation	Biomarker interpretation	Required accompanying assessment	Evidence-based clinical implication
Expected early postoperative inflammation	CRP commonly rises; PCT may rise transiently after major surgery	Procedure type, postoperative day, clinical stability, operative magnitude	Avoid diagnosing infection from an isolated early elevation
Suspected postoperative bacterial infection	Persistent or increasing PCT may increase suspicion; CRP indicates ongoing inflammation but is less specific	Examination, cultures, imaging, organ function, wound or drain assessment	Biomarkers may support further investigation but cannot confirm infection independently
Clinically improving patient after source control	Declining PCT supports reduction in bacterial activity; CRP may decline more slowly	Confirmation of adequate drainage, repair, debridement, or other source control	PCT trend may support antibiotic discontinuation when the overall clinical picture is reassuring
Persistent fever or organ dysfunction	Static or increasing biomarker concentrations may indicate unresolved inflammation or infection	Repeat cultures, imaging, source-control reassessment, evaluation for non-infectious complications	Biomarkers should trigger reassessment rather than automatic antibiotic escalation
Localized surgical-site infection	CRP may rise; PCT may remain low if systemic involvement is absent	Direct wound examination, microbiological sampling, imaging when deep infection is suspected	A low PCT should not be used to exclude localized infection
Monitoring recovery	Serial CRP reflects the broad inflammatory trajectory; serial PCT may reflect changes in systemic bacterial activity	Clinical course and laboratory trends	Combined trends may improve contextual interpretation
Determining antibiotic duration	PCT has stronger supporting evidence than CRP	Clinical improvement, microbiology, source control, absence of new infection	Use PCT as an adjunctive stopping aid rather than an independent rule
Suspected treatment failure	Persistent elevation of either biomarker is non-specific	Imaging, cultures, operative review, assessment for resistant organisms or inadequate source control	Treatment decisions should be based on identification and correction of the underlying cause

The overall evidence indicated that CRP and PCT have complementary rather than interchangeable roles. CRP was consistently characterized as a sensitive, accessible, and inexpensive marker of inflammatory activity, but its frequent elevation after surgery limited its specificity for bacterial infection. PCT demonstrated comparatively greater association with systemic bacterial infection and a more rapid decline after effective infection control, although postoperative and other non-infectious elevations reduced its diagnostic specificity.

The most consistent clinical advantage of PCT was observed in antibiotic-stewardship strategies, particularly in supporting discontinuation or shortening of therapy in critically ill populations (5,6,8). The evidence for this application was stronger than the evidence supporting PCT as a stand-alone diagnostic test. However, much of the interventional evidence was indirect for surgical practice because it originated from heterogeneous intensive-care populations.

Direct surgical evidence supported the interpretation of serial PCT and CRP trends following major abdominal surgery but did not establish a universal threshold or protocol applicable across all operations (7). The reviewed literature therefore supported biomarker-assisted rather than biomarker-directed management. Clinical assessment, microbiological investigation, imaging, and adequate surgical source control remained the decisive components of infection management.

DISCUSSION

This structured narrative review indicates that procalcitonin and C-reactive protein have complementary rather than interchangeable roles in the assessment of surgical and postoperative infections. CRP is an accessible and sensitive indicator of inflammatory activity, but its routine elevation following tissue injury limits its ability to distinguish bacterial infection from uncomplicated postoperative inflammation. PCT is comparatively more closely associated with systemic bacterial activity and has more supportive evidence for guiding antibiotic discontinuation. Neither biomarker, however, has sufficient diagnostic specificity or clinical reliability to replace examination, microbiological testing, imaging, or assessment of surgical source control.

The distinction between the two biomarkers is principally explained by their biological response and postoperative kinetics. CRP is produced as part of a broad hepatic acute-phase response and may increase

substantially after surgery, trauma, infection, ischemia, or other inflammatory insults (1). Its elevation therefore confirms the presence of inflammation but does not establish its cause. PCT is normally present at very low concentrations and increases more prominently during systemic bacterial inflammation, although major surgery, trauma, burns, shock, and organ dysfunction may also produce non-infectious elevations (2,3). The comparatively faster decline of PCT following control of bacterial infection provides a biological rationale for its use in serial antibiotic reassessment.

The diagnostic evidence nevertheless cautions against treating PCT as a stand-alone marker of postoperative infection. The meta-analysis by Wacker et al. demonstrated moderate diagnostic accuracy for sepsis and emphasized that PCT should supplement rather than replace clinical judgment (4). This limitation is particularly important after surgery because both sterile inflammation and bacterial infection may elevate PCT during the early postoperative period. Diagnostic interpretation should consequently incorporate the timing of measurement, magnitude of surgery, baseline clinical condition, organ function, and direction of serial change.

Evidence from major abdominal surgery suggests that serial PCT and CRP measurements may assist in identifying patients whose postoperative course deviates from expected recovery (7). Persistent elevation, failure to decline, or a secondary increase may justify further investigation, but these patterns do not identify the anatomical cause of deterioration. Anastomotic leakage, intra-abdominal collection, tissue ischemia, infected prosthetic material, and non-infectious complications may produce overlapping clinical and biochemical findings. Biomarker abnormalities should therefore prompt targeted clinical reassessment and imaging rather than automatic initiation or escalation of antibiotics.

CRP remains clinically useful despite its lower specificity for bacterial infection. Its wide availability and lower cost make repeated measurements feasible in many healthcare settings. A progressively declining CRP concentration may support an uncomplicated recovery, whereas persistent elevation or a secondary rise may indicate continuing inflammation. However, CRP may remain elevated after bacterial control because of ongoing tissue repair and postoperative inflammatory activity. Requiring CRP normalization before discontinuing antibiotics may therefore result in unnecessarily prolonged treatment.

The strongest comparative advantage of PCT lies in antimicrobial stewardship rather than independent diagnosis. The PRORATA trial demonstrated that a PCT-guided strategy could reduce antibiotic exposure in critically ill patients without increasing mortality or treatment failure (5). The randomized trial by de Jong et al. similarly supported shorter antibiotic treatment when serial PCT measurements were incorporated into clinical decision-making (6). Meta-analytic evidence has further supported the potential of PCT-guided protocols to reduce antimicrobial exposure in critically ill adults (8).

These findings are clinically important but must be interpreted cautiously in surgical practice. The major PCT-guided trials enrolled heterogeneous intensive-care populations rather than exclusively postoperative patients with clearly defined surgical infections. The evidence therefore supports the general safety and feasibility of biomarker-assisted antibiotic discontinuation but does not establish a universal PCT protocol for every surgical-site infection, intra-abdominal infection, or postoperative septic episode. The applicability of PCT-guided strategies is likely to depend on infection site, severity of illness, operative procedure, adequacy of source control, and the presence of immunosuppression or organ dysfunction.

Effective source control remains fundamental to the treatment of surgical infection. No biomarker can compensate for an undrained abscess, anastomotic disruption, devitalized tissue, infected foreign material, or another persistent anatomical source. A falling PCT concentration may support antibiotic discontinuation after successful drainage, debridement, repair, or removal of the infectious focus, particularly when clinical improvement and microbiological findings are concordant. Conversely, a low or declining PCT concentration should not delay imaging or operative reassessment when the patient continues to deteriorate.

The distinction between localized and systemic infection is also clinically relevant. A localized superficial or deep surgical-site infection may not produce a marked systemic PCT response. A low PCT concentration therefore cannot independently exclude wound infection, localized intra-abdominal infection, or infection associated with an implanted device. Direct examination, microbiological sampling, and imaging remain more informative in these circumstances. CRP may be elevated in localized infection but provides limited information regarding bacterial severity or the need for prolonged systemic antibiotic therapy.

The reviewed evidence supports an integrated rather than hierarchical interpretation of PCT and CRP. In a clinically improving patient with adequate source control, falling PCT and CRP concentrations strengthen the impression of infection resolution. A rapid decline in PCT accompanied by a slower reduction in CRP may represent expected biological kinetics rather than treatment failure. Persistent elevation of both biomarkers may increase concern for unresolved inflammation, but escalation of treatment should depend on confirmation of an infectious source and not solely on laboratory values.

Discordant biomarker patterns require particular caution. An elevated CRP with a low or declining PCT may reflect postoperative tissue inflammation, a localized infection, or a non-bacterial complication. A persistently elevated PCT with declining CRP may indicate continuing systemic bacterial activity, but it may also be influenced by severe trauma, shock, renal dysfunction, or another major inflammatory insult. Biomarker interpretation should consequently be based on serial trajectories and pretest probability rather than isolated numerical thresholds.

The available evidence did not establish a universally applicable PCT or CRP cut-off for surgical patients. Thresholds differed across studies, as did measurement intervals, surgical procedures, infection definitions, and criteria for antibiotic discontinuation. A concentration that is clinically meaningful after minor surgery may have different implications after major abdominal, cardiothoracic, transplant, or trauma surgery. Percentage reduction from baseline may be more informative than an isolated value in some settings, but this approach also requires validation in defined surgical populations.

From an implementation perspective, the higher cost and variable availability of PCT testing may restrict routine use in resource-limited settings. CRP is more widely accessible and remains useful for longitudinal monitoring, but its lower specificity limits its capacity to reduce antibiotic exposure independently. Selective PCT measurement in patients with diagnostic uncertainty or prolonged antibiotic treatment may be more feasible than routine measurement in every surgical patient. Cost-effectiveness should be evaluated in relation to reductions in antibiotic use, adverse drug effects, laboratory expenditure, length of stay, and antimicrobial resistance.

This review has several limitations. The literature search was focused rather than exhaustive, and study selection was not performed through formal dual independent screening. A standardized risk-of-bias assessment was not undertaken, and the narrative synthesis may therefore be affected by selection and interpretive bias. The evidence base was heterogeneous and included foundational biomarker research, diagnostic studies, randomized stewardship trials, systematic reviews, and mixed intensive-care populations. Several studies provided indirect rather than surgical-specific evidence, and the absence of quantitative pooling prevented estimation of a summary diagnostic or treatment effect.

The reference base also contained relatively limited contemporary surgical evidence. Differences in biomarker thresholds, timing of measurements, operative procedures, definitions of infection, adequacy of source control, and antibiotic protocols restricted direct comparison. These limitations reinforce the need to avoid prescriptive claims and to interpret PCT and CRP as adjunctive components of a broader clinical assessment.

Future investigations should prioritize prospective, multicentre studies conducted in clearly defined surgical populations. Trials should separately evaluate surgical-site infection, postoperative intra-

abdominal infection, trauma-related infection, transplant infection, and postoperative sepsis. Standardized reporting of procedure type, postoperative sampling time, baseline biomarker concentration, absolute values, percentage change, organ function, microbiological findings, and source-control status would improve comparability.

Randomized studies should determine whether procedure-specific PCT algorithms can safely reduce antibiotic duration after adequate source control. Future research should also compare PCT-guided care with structured clinical reassessment rather than with poorly defined usual care. Composite decision models integrating biomarker trajectories, clinical variables, microbiological findings, and imaging may provide greater diagnostic and stewardship value than either PCT or CRP alone. Cost-effectiveness, implementation feasibility, and patient-centred outcomes should be evaluated alongside antibiotic exposure and mortality.

CONCLUSION

Procalcitonin and C-reactive protein provide complementary information in the assessment of surgical and postoperative infections. CRP is inexpensive, widely available, and useful for monitoring the overall inflammatory trajectory, but its frequent elevation after surgery limits its specificity for bacterial infection and its independent value in antibiotic decisions. PCT is comparatively more closely associated with systemic bacterial activity and has stronger evidence as an adjunct to antibiotic-discontinuation strategies, although much of this evidence is derived from heterogeneous intensive-care populations rather than exclusively surgical cohorts. Neither biomarker should be used in isolation to diagnose infection, determine treatment failure, or mandate continuation or discontinuation of antibiotics. Their greatest clinical value arises from serial interpretation alongside the patient's clinical course, microbiological findings, imaging results, and confirmation of adequate surgical source control. Surgical-specific trials are required to establish standardized measurement schedules, clinically meaningful thresholds, and safe biomarker-guided stewardship protocols.

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