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Herbal Medicines in Perioperative Care: From Herb-Drug Interactions to a Risk-Stratified Medication-Reconciliation Framework

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ABSTRACT

Herbal products are reported by surgical patients, but medication histories may omit the formulation, dose, and time of last use. This narrative mini-review examines how such uncertainty affects perioperative risk assessment. We prioritized literature published from January 2020 through December 2025 and included earlier interaction studies and 2026 professional guidance. Potential hazards include altered hemostasis, drug metabolism and transport, sedation, cardiovascular and metabolic effects, and product contamination; clinical importance depends on the preparation, concurrent medicines, and planned procedure. Evidence of perioperative benefit is limited, and findings from small clinical studies or animal models do not justify routine use. We propose an unvalidated medication-reconciliation workflow that records product identity and exposure, considers mechanisms alongside patient and procedural vulnerability, and assigns a provisional low, moderate, high, or uncertain action category. Uncertain exposure calls for label verification and clinical review, especially before emergency or bleeding-sensitive procedures. Discontinuation and postoperative reintroduction should be individualized because one stop interval cannot be applied to all products. The workflow requires prospective evaluation, as do the effects of chemically characterized preparations on surgical outcomes.

1. INTRODUCTION

Herbal products are reported in preoperative surveys, yet patients do not always disclose them when asked about medicines [1, 2]. Perioperative reviews describe possible effects on hemostasis, drug disposition, and sedation, but procedure-specific clinical evidence is often limited [3–5]. Because marketed preparations differ in composition and regulatory review, the product label, formulation, and last dose deserve explicit documentation [6, 7].

During surgery, even modest pharmacological effects may become clinically relevant. Changes in platelet function can be important in patients receiving anticoagulants or antiplatelet agents, undergoing neuraxial procedures, or requiring extensive tissue dissection. Enzyme induction or inhibition may alter the effects of opioids, benzodiazepines, immunosuppressants, antiemetics, and cardiovascular medicines. Sedative, sympathomimetic, diuretic, and hypoglycemic properties may also interact with fasting, fluid shifts, anesthetic drugs, and postoperative analgesia. Mechanistic studies and case reports are much more common than controlled perioperative trials [3–5].

The management question is therefore practical: how should a perioperative team act when a patient reports an herbal product but its identity, formulation, dose, or last exposure is uncertain? This mini-review develops a product-centered, risk-stratified approach that links the likely mechanism to patient vulnerability and procedural consequence. The proposed framework is intended to structure clinical

documentation and support multidisciplinary decision-making; it has not been validated as a predictive clinical tool.

2. LITERATURE REVIEW APPROACH

We used a targeted narrative search. PubMed, established pharmacology reviews, and professional or regulatory websites were consulted; Crossref was used to check bibliographic records. Search concepts combined herbal medicine, herbal preparation, or dietary supplement with perioperative care, anesthesia, surgery, herb-drug interaction, bleeding, CYP enzymes, sedation, medication reconciliation, electronic health records, product identity, formulation, dose, last dose, and emergency surgery. Publications from January 2020 through December 2025 were prioritized; earlier interaction studies and relevant 2026 professional guidance were also retained [5, 8, 9].

We retained English-language human studies, mechanistic and pharmacokinetic studies, systematic reviews, and professional or regulatory guidance that could inform perioperative risk. Animal studies were used only to illustrate the limits of translation. Titles and abstracts were screened for relevance, full texts were consulted where available for claims used, and reference metadata were checked against publisher records or DOI landing pages. The synthesis is descriptive; no pooled effect estimates or formal risk-of-bias score is claimed.

3. WHY PERIOPERATIVE EXPOSURE IS DIFFERENT

Perioperative risk depends on the herbal product, the patient, the planned procedure, and concurrent conventional treatment.

A standardized low-dose product taken before a minor procedure is not equivalent to several concentrated extracts taken before major cancer surgery. Product identification is often incomplete because botanical species, plant parts, extraction methods, doses, batches, contaminants, and undeclared ingredients may vary considerably between brands. Heavy metal contamination and hidden ingredients have been reported in some herbal products [10]. Dietary supplements are not regulated through the same approval process as medicines, and products marketed as a single herb may contain multiple ingredients [5, 7, 11].

Five questions organize the assessment. What is the potential effect on hemostasis? Could enzymes or transporters change the exposure to an anesthetic or other high-risk medicine? Could pharmacodynamic effects add sedation, hypotension, arrhythmia, vasoconstriction, hypoglycemia, or serotonergic activity? Does the patient have hepatic, renal, respiratory, or hematologic comorbidity that could increase susceptibility to adverse perioperative effects? Finally, has the exposure been communicated accurately? Patients may mention tablets but omit teas, powders, traditional formulas, gummies, or intermittent use. The 2024 perioperative review also emphasizes that many reported interactions remain supported mainly by limited or indirect evidence [5].

4. MAJOR HERBAL PRODUCTS RELEVANT TO PERIOPERATIVE CARE

4.1 Garlic, Ginkgo, Ginseng, and Ginger

Garlic preparations contain organosulfur compounds that may influence platelet aggregation and vascular signaling. *Ginkgo biloba* provides a plausible bleeding mechanism through ginkgolides and platelet-activating-factor antagonism. Ginseng has diverse pharmacological properties, and its ginsenosides may affect platelet function, glucose regulation, blood pressure, and metabolic processes. Ginger constituents can affect thromboxane and platelet pathways, although dose and preparation matter. These findings support careful medication history-taking rather than assuming that every user has an increased bleeding risk or requires cancellation of surgery. The concern is greater when herbal products are used with aspirin, P2Y₁₂ inhibitors, warfarin, direct oral anticoagulants, heparins, or nonsteroidal anti-inflammatory drugs [3, 5, 12, 13].

The clinical ginkgo literature is sparse and heterogeneous rather than a consistent demonstration of a large bleeding effect [13]. For garlic and ginger, much of the evidence is mechanistic or comes from nonoperative populations. The defensible action is to record the exact product and dose, review concurrent antithrombotics, and discuss the total hemostatic risk with the prescriber and anesthesiologist. An essential prescription antithrombotic should not be stopped simply to compensate for an unverified supplement interaction.

4.2 St John's Wort

St John's wort has comparatively strong clinical evidence for herb-drug interactions [14]. Hyperforin activates pregnane X receptor signaling and can induce CYP3A4, CYP2C9, CYP2C19, and P-glycoprotein; the magnitude depends on the preparation and its hyperforin content [15–17]. Reduced exposure has been demonstrated for susceptible medicines. In perioperative care, a narrow therapeutic window or a need for predictable exposure makes this particularly relevant. Enzyme and transporter activity may persist after the last dose, so the record should contain the formulation and exposure date rather than an assumed 24-hour washout [5, 14–16].

4.3 Echinacea and Immune-Active Products

Echinacea preparations differ by species, plant part, and extraction method. Possible immune activity is not evidence of prevention of perioperative or surgical-site infection. Allergic reactions and possible interactions with immunosuppressive therapy are more pertinent concerns [4, 5]. A patient taking transplant immunosuppressants (for example, tacrolimus or cyclosporine) or biologic therapy should discuss the exact preparation with the treating specialist. Direct evidence does not support recommending echinacea as a perioperative anti-infective intervention.

4.4 Valerian, Kava, and Other Sedative Products

Valerian, kava, passionflower, melatonin-containing mixtures, and cannabis-derived products are heterogeneous exposures. Depending on the preparation and co-medications, sedative effects could add to those of anesthetics, benzodiazepines, or opioids; direct perioperative evidence for delayed emergence, respiratory depression, or delirium is limited. Kava has a separate hepatotoxicity concern. Patients may describe these products only as sleep aids, so preoperative questions should include teas, tinctures, gummies, and intermittent or night-before-surgery use [4–6].

4.5 Curcumin and Bromelain

Curcumin has anti-inflammatory and antioxidant activity in experimental systems, but oral bioavailability, formulation, and dose vary widely. A 2021 review described plausible mechanisms while emphasizing the limits of translation and the lack of formulation standardization [18]. In a rat abdominal surgery model, curcumin did not consistently reduce adhesion severity, which illustrates why a laboratory signal cannot be presented as an established clinical benefit [19].

Bromelain is a proteolytic enzyme preparation. A 2023 systematic review reported possible benefits for selected inflammatory or postoperative outcomes but also substantial heterogeneity [20]. An open-label prospective study of 100 patients undergoing maxillofacial trauma surgery reported less edema and lower anti-inflammatory use in a bromelain-containing regimen; the study was not blinded and included other nutraceutical ingredients [21]. Bromelain is therefore a possible adjunct under study, not a replacement for surgical hemostasis, analgesia, or standard edema management.

5. MECHANISMS THAT MATTER IN ANESTHESIA AND SURGERY

5.1 Hemostasis and Bleeding

The perioperative question is not simply whether a botanical inhibits platelet aggregation in vitro. The relevant clinical question is whether the planned procedure, together with the patient's existing risk factors, could compromise the overall capacity to maintain adequate hemostasis. Combination antithrombotic therapy, thrombocytopenia, liver disease, renal dysfunction, a history of abnormal bleeding, high-consequence neurosurgical or ophthalmic procedures, and neuraxial anesthesia all raise the stakes. When a product is unknown or multi-ingredient, the safer course is to document the exposure, assess the complete bleeding history, and obtain anesthesia or surgical input rather than rely on an internet stop-time chart [3, 5, 13].

5.2 Cyp Enzymes, Transporters, and Anesthetic Exposure

Herbal products may alter the disposition or pharmacodynamic effects of prescribed medicines. Clinical significance depends on formulation, exposure, and the affected drug [12]. BABINE scores published clinical descriptions of herb-drug interactions; it does not establish anesthetic effects [22]. A recent review describes pharmacokinetic mechanisms in Chinese herbal formulas [23]. Studies of *Xylopiia aethiopica* with antidepressants and alkaloid effects on OATP1B1 offer non-anesthetic examples of possible

interactions [24, 25]. Neither demonstrates a clinical interaction with an anesthetic. Broader reviews describe both documented and potential herb-drug interactions [26, 27]. The perioperative record should identify particularly vulnerable medicines, especially those with narrow therapeutic windows, rather than treat every in vitro result as a clinical interaction.

5.3 Cardiovascular, Endocrine, and Respiratory Effects

Ginseng and stimulant-containing products may affect blood pressure, heart rate, or glucose. Ephedra-containing products are more concerning because sympathomimetic activity can provoke hypertension, tachycardia, or arrhythmia. Diuretic or laxative mixtures may worsen dehydration and electrolyte abnormalities during fasting. Sedative products can impair airway protection and amplify opioid-related respiratory depression. These potential effects are often more actionable than a speculative antioxidant benefit [5].

5.4 Inflammation, Oxidative Stress, and Wound Healing

Oxidative stress and inflammatory signaling are relevant to tissue injury, but changing a laboratory marker does not guarantee better wound healing. Curcumin, garlic organosulfurs, gingerols, and bromelain may have anti-inflammatory or antioxidant properties, but surgical outcomes are also influenced by perfusion, infection control, nutrition, glycemic control, smoking, immunosuppression, and operative technique. Human evidence should be reported by outcome and study design rather than converted into a general claim that herbs speed recovery [18–21, 28].

6. RESULTS

6.1 Evidence for Perioperative Benefit

The narrative synthesis identified limited evidence for perioperative benefit. The 2024 bromelain study enrolled 100 patients prospectively, but it was open-label and used a combination regimen [21]. The 2024 curcumin wound-healing study was conducted in rats and cannot justify routine human supplementation [28]. A 2025 Brief Communication summarizes separate small studies of Kampo formulas in dental procedures, gynecologic laparoscopic surgery, and breast surgery; it does not report a new trial, and the formulas cannot be generalized to over-the-counter supplements [29]. A 2024 review of perioperative hypothermia discusses herbal, acupuncture, and warming interventions together, so it cannot isolate a benefit from a single herbal product [30].

6.2 Evidence Certainty and Transferability

Taken together, the available findings are best treated as hypothesis-generating or procedure-specific. An herbal product should not displace evidence-based thromboprophylaxis, antibiotic prophylaxis, multimodal analgesia, warming, nutrition, or wound care. The immediate clinical value of phytopharmacology is more likely to come from accurate exposure recognition and better-designed trials of standardized products than from a blanket recommendation for perioperative use [21, 28–30].

7. A RISK-STRATIFIED MEDICATION-RECONCILIATION FRAMEWORK

An anesthetic-practice interaction review and BABINE, a scale for assessing published clinical reports of herb-drug interactions, already address parts of this problem [9, 22]. The workflow proposed here applies a product and exposure record to a specific surgical decision, including the consequences of an unidentified preparation or unknown last dose. It does not estimate the probability of harm or replace existing interaction assessment.

The proposed clinical workflow is presented in Figure 1. It begins with identification of the exact herbal exposure and then integrates plausible pharmacological hazards with patient-specific and procedure-specific factors. A provisional low, moderate, high, or uncertain category guides documentation, individualized withholding when feasible, specialist consultation, and the intensity of perioperative monitoring. The framework is intended to support clinical judgment and communication; it is not a validated prediction tool.

These categories are proposed action triggers. Low means the product is identified and review finds no relevant hazard with the current medicines or planned procedure; it does not prove safety. Moderate denotes a plausible hazard for which an individualized monitoring or withholding plan is feasible. High

denotes a credible hazard combined with a vulnerable drug or patient, or a procedure where bleeding or delayed recovery could have serious consequences; it calls for senior clinical review, not automatic cancellation. Uncertain applies when ingredients, dose, timing, or evidence needed for assignment cannot be established. Unknown exposure should not be counted as low risk. These descriptors have not been validated against clinical outcomes.

ENTRY: Patient reports an herbal product or supplement	
STEP 1 - Identify the exposure	Species, brand, formulation, dose, frequency, batch, and last dose
STEP 2 - Determine pharmacological hazards	Bleeding, CYP or transporter effects, sedation, cardiovascular, glucose, hepatic, or renal effects
STEP 3 - Assess patient and procedure	Antithrombotics, organ dysfunction, thrombocytopenia, polypharmacy, neuraxial or bleeding-sensitive surgery, emergency status
DECISION - Provisional action category	Low Moderate High Uncertain
ACTION - Matched response	Low: document Moderate: review/hold if indicated High: senior review and tailored plan Uncertain: clarify exposure and monitor

Figure 1. Risk-stratified medication-reconciliation framework for perioperative management of herbal medicines and dietary supplements.

7.1 Emergency Surgery and Uncertain Exposure

Advice written for elective surgery cannot simply be transferred to an emergency. The 2026 Royal College of Anaesthetists article notes the lack of a dedicated emergency protocol and recommends case-by-case assessment after the product is characterized [8]. The absence of a washout interval is not evidence of safety. The team should record the product and last known exposure, inspect the container or a photograph when possible, identify antithrombotic and sedative co-medication, and communicate the uncertainty during the anesthesia briefing.

Management should be guided by the suspected mechanism. When bleeding risk is a concern, the anesthesiologist should assess the suitability of neuraxial or regional anesthesia based on the overall hemostatic profile and local guidelines. If enzyme induction or inhibition is possible, drugs with narrow therapeutic windows should be reviewed and titrated to clinical effect. When sedative effects are suspected, airway, respiratory, and recovery monitoring should account for the combined exposure. If the product cannot be identified, the correct category is uncertain, with documentation, senior review, and monitoring rather than an invented stop-time rule [5, 8].

7.2 Electronic Medication Reconciliation: A Proposed Safety Process

Medication reconciliation is partly a documentation problem. The RCoA article proposes prompts that ask specifically about herbal medicines and electronic records that retain the exposure and provide embedded flags or alerts [8]. A practical pathway should separate what the patient reports from the clinical interpretation: the record should retain the product name, manufacturer and formulation if known, dose and frequency, last exposure, reason for use, and confidence of identification. Decision support could then display the suspected hazard category, relevant interacting medicines, and the need for pharmacy or anesthesia review. Product-specific prompts and their effects on disclosure, alert burden, and patient outcomes should be tested before routine deployment. Such electronic records increasingly sit within cloud- and IoT-connected smart-healthcare systems [31].

7.3 Products Outside the Traditional Herb List

A product-centered framework must also handle newer or less familiar exposures. The 2026 RCoA case describes lion's mane (*Hericium erinaceus*) disclosed on the day of surgery; possible hypoglycemic and antiplatelet effects are mentioned, but their clinical significance is not quantified [8]. Cannabidiol products, concentrated green-tea extracts, mushroom-derived supplements, and multi-ingredient sleep products create the same identification problem. They should enter the framework through the product and formulation fields, not through an assumption that a familiar category has stable pharmacology. When evidence is limited to in vitro findings or extrapolation, that limitation should be visible in the management decision [8, 9]. AI methods are also being applied to characterize food, nutraceutical and biotechnology products of this kind [32].

7.4 Evidence-to-Action Matrix

Table 1 operationalizes the proposed framework by linking common herbal exposure patterns to plausible pharmacological hazards, patient- and procedure-specific modifiers, and a documented perioperative action. The matrix is not designed to assign a numerical probability of harm or to replace clinical judgment. Instead, it distinguishes situations in which a clinically meaningful interaction is reasonably supported, such as *St John's wort* use with susceptible medicines, from situations in which the evidence, product identity, dose, or formulation is insufficiently characterized. The final column records the directness and type of evidence, not a graded probability of harm or the patient risk category.

The table 1 highlights that the same product may require different management depending on concurrent antithrombotic therapy, organ dysfunction, polypharmacy, anesthesia type, and the consequences of perioperative bleeding or delayed recovery. In particular, unknown or multi-ingredient products and newer products with limited human evidence should be categorized as uncertain, prompting label verification, multidisciplinary review when appropriate, and enhanced monitoring rather than reliance on unsubstantiated universal stop-time recommendations. Thus, the matrix is an evidence-to-action aid for documentation and clinical communication and should be prospectively evaluated before use as a formal clinical decision rule.

Table 1. Evidence-to-action matrix for perioperative herbal medicine management.

Exposure pattern	Mechanism or evidence	Patient modifiers	Procedure modifiers	Action to document	Evidence basis
<i>St John's wort</i> ; known formulation	PXR/CYP3A4 and transporter induction; clinical exposure changes reported [9], [15], [16], [17]	Narrow-therapeutic-index drugs; polypharmacy	Major surgery; drugs dependent on predictable exposure	Record last dose and formulation; review interacting drugs; individualized washout and postoperative restart	Human PK; non-anesthetic
Garlic, ginkgo, ginger, ginseng, bromelain	Mechanistic or mixed clinical platelet/coagulation evidence [3], [5], [13], [20]	Antithrombotics; thrombocytopenia; liver or renal disease	Bleeding-sensitive or neuraxial procedure	Do not infer a universal stop time; assess total hemostatic risk and seek anesthesia review	Mixed human and mechanistic
Valerian, kava, passionflower, multi-ingredient sleep products	Plausible additive CNS depression; direct perioperative trials limited [4], [5], [9]	Opioids, benzodiazepines, respiratory disease, frailty	General anesthesia; expected prolonged recovery	Record last exposure; plan airway and recovery observation; avoid unreviewed reintroduction	Mostly mechanistic
Unknown or multi-herb product	Identity, dose, contaminants, and interactions cannot be resolved [7], [8], [10], [11]	Polypharmacy; organ dysfunction; prior adverse reaction	Emergency surgery or high-consequence procedure	Classify as uncertain; inspect label; senior or pharmacist consultation; enhanced monitoring	Exposure unresolved
Emerging product such as lion's mane or CBD	Evidence may be in vitro, case-based, or formulation-dependent [8], [9]	Hypoglycemia, sedation, hepatic disease, interacting medicines	Procedure and anesthetic plan determine consequence	Capture exact product; avoid extrapolating from a different species or extract; document evidence limits	Early, indirect evidence

8. PREOPERATIVE ASSESSMENT AND DISCONTINUATION

A concise medication history can begin with four direct questions: Which herbal products, teas, powders, traditional formulas, or gummies do you use? For each product, what are the brand, formulation, dose, and dosing schedule, and when was it last used? Why do you take the product? Have you had bleeding, palpitations, sedation, rash, jaundice, or a suspected interaction? Patients should be asked to bring the container or a photograph of the label. This is more reliable than asking only whether they take medications [5].

A single evidence-based stop interval has not been established for every herbal product. The 2024 perioperative review reports a broad one- to two-week recommendation before elective surgery [5]. The UK Clinical Pharmacy Association position statement independently recommends withholding herbal medicines one or two weeks before elective surgery [33]. These general recommendations do not establish a product-specific washout; the decision should account for the preparation, exposure, other medicines, patient condition, and procedure. *St John's wort* deserves particular review because enzyme induction may

outlast the last dose. After surgery, reintroduction of a product with possible bleeding or sedative effects should follow assessment of hemostasis, oral intake, organ function, and interacting prescriptions.

The practical assessment points are summarized in Table 2. The table outlines commonly encountered herbal and multi-herb products, their relevant constituents, potential perioperative concerns, limitations of the available evidence, and practical management considerations. It is intended to support structured medication reconciliation and individualized clinical decision-making rather than classify any product as universally safe or unsafe. Management should consider the exact product, formulation, dose, frequency, timing of the last exposure, concomitant prescription medicines, patient comorbidities, anesthetic plan, and procedure-specific bleeding risk. In particular, possible platelet-related effects may be more consequential in patients receiving antithrombotic therapy or undergoing neuraxial or bleeding-sensitive procedures, whereas sedative products require caution in the presence of general anesthesia, opioids, respiratory disease, or frailty. Unknown, multi-ingredient, or poorly characterized products should be documented as uncertain exposures and reviewed with the anesthesia, surgical, or pharmacy team when clinically relevant.

Table 2. Practical perioperative assessment of commonly encountered herbal products.

Product or class	Relevant constituents	Main concern	Evidence interpretation	Practical management
Garlic	Organosulfur compounds	Possible platelet inhibition and bleeding when combined with antithrombotics	Mechanistic and heterogeneous clinical data	Record dose and last use; consider holding a nonessential product before elective surgery; coordinate with anesthesia
Ginkgo biloba	Ginkgolides, bilobalide	Possible platelet-activating-factor antagonism	Case reports and mixed clinical evidence	Avoid a rigid 36-hour rule; assess procedure and antithrombotic therapy
Ginseng	Ginsenosides	Possible platelet, glucose, blood-pressure, and metabolic effects	Preparation-dependent pharmacology	Review glucose and cardiovascular risk; hold a nonessential product for elective surgery when risk is relevant
<i>St John's wort</i>	Hyperforin and hypericin	CYP3A4, CYP2C9, CYP2C19, and P-glycoprotein induction	Strongest herb-drug interaction signal; persistence after stopping matters	Document formulation and last dose; review interacting medicines and allow an individualized washout
Valerian or kava	Valerenic acids or kavalactones	Potential additive sedation; kava liver toxicity concern	Plausible pharmacodynamic risk; direct trials limited	Ask about last dose; avoid perioperative use unless explicitly managed by anesthesia
Curcumin	Curcuminoids	Variable bioavailability; possible antiplatelet and drug-metabolism effects	Human surgical evidence limited; animal data are not generalizable	Do not recommend routinely; assess formulation, bleeding risk, and interacting drugs
Bromelain	Proteolytic enzymes	Possible bleeding or additive effects with anticoagulants; edema benefit uncertain	Small clinical studies and heterogeneous systematic reviews	Treat as an investigational adjunct; coordinate with surgeon and anesthesia
Echinacea or multi-herb formulas	Species- and product-dependent	Allergy and possible interactions with immunosuppressive therapy; product identity may be uncertain	Clinical perioperative benefit is unproven; effects vary by preparation	Obtain the label; do not assume standardization or safety

9. POSTOPERATIVE REINTRODUCTION AND PATIENT SAFETY

Restarting an herbal product after surgery should be treated as a medication decision. Nonessential products with possible effects on bleeding, sedation, fluid balance, glucose, or drug metabolism should usually be delayed until hemostasis is stable, oral intake has resumed, liver and kidney function are acceptable, and potential interactions with prescribed medicines have been reviewed. This is especially important after a procedure with ongoing bleeding risk or when postoperative anticoagulation is required. Patients need a written plan rather than a vague instruction to resume usual medicines.

Pharmacovigilance remains important after discharge. New bruising, persistent bleeding, agitation, excessive somnolence, hypotension, palpitations, jaundice, dark urine, or an unexplained change in drug response should prompt clinical review and consideration of the supplement as a possible contributor. Serious suspected reactions should be reported through the relevant national system, and the product label or batch information should be preserved when available.

10. RESEARCH PRIORITIES AND EVIDENCE GAPS

Few well-designed perioperative studies use clearly characterized herbal products. Future studies should report botanical species, plant part, extraction method, active markers, dose, batch testing, and timing of the last dose. They should also specify the procedure and anesthesia, antithrombotic co-medication, transfusion, estimated blood loss, hemostatic interventions, sedation and respiratory outcomes, relevant drug concentrations, wound outcomes, and adverse events. Multi-herb formulations should not be treated as single compounds.

Pharmacokinetic studies should examine the anesthetic and analgesic substrates used in contemporary practice and distinguish oral supplements from traditional decoctions and topical preparations. Large observational studies can examine patterns of disclosure, discontinuation, and adverse events, but they must account for confounding by indication. Reporting standards should state whether participants were asked about nonprescription products and how each product was verified. Without that detail, a negative study may simply be an exposure-misclassification study.

10.1 Verification and Implementation Priorities

Electronic medication-reconciliation interventions reduce medication-level discrepancies, particularly omissions, but effects on patient-level outcomes are less consistent [34]. The World Health Organization identifies transitions of care as a medication-safety priority and calls for structured processes and better information quality [35]. Neither source establishes that a herbal-product alert improves perioperative outcomes. A dedicated electronic health record field for the exact product, formulation, dose, last use, and certainty of identification is therefore a proposal that requires implementation testing.

Substrate-specific pharmacology should also be tested rather than assumed. An *in vitro* cannabinoid study found concentration-dependent inhibition across several CYP pathways [36]. In contrast, a randomized volunteer study found no clinically meaningful effect of *St John's wort* on intravenous fentanyl pharmacokinetics or pharmacodynamics, whereas a clinical probe-drug study found increased oral midazolam clearance after longer-term *St John's wort* exposure [37, 38]. A review of dietary supplements describes plausible hemostatic mechanisms but insufficient controlled evidence for a uniform anticoagulant effect [39]. Finally, analytical studies document undeclared synthetic ingredients in products marketed as herbal, supporting an explicit uncertain category when the label or batch cannot be verified [40].

11. CONCLUSION

Selected herbal products can influence perioperative pharmacology, particularly hemostasis, drug metabolism, sedation, cardiovascular physiology, and inflammatory outcomes. Evidence of clinical benefit is limited and less consistent than evidence of possible biological effects or interaction risks. A safer approach is structured disclosure, product-specific assessment, communication among the patient, surgeon, anesthesiologist, and pharmacist, and individualized discontinuation and reintroduction. Elective discontinuation and postoperative reintroduction should be individualized after considering persistent enzyme effects, bleeding risk, organ dysfunction, and uncertain product composition. Herbal medicines should be incorporated into perioperative care only when their identity, indication, risk, and evidence are transparent.

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