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DHATUPAKA AS A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING *KṢHAYA* AND TISSUE WASTING IN TUBERCULOSIS – A REVIEW ARTICLE

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ABSTRACT

Background: Tuberculosis (TB) is associated not only with infection but also with weight loss, undernutrition, and progressive tissue wasting. Ayurveda describes a comparable clinical state through *Kṣaya* and *Rajayakṣma*, characterized by depletion of the body tissues (*Dhatu*). *Dhatupaka*, referring to pathological tissue-level change associated with impaired tissue transformation, may provide an additional perspective for understanding this process. **Objective:** To examine the possible relevance of *Dhatupaka* in understanding TB-associated tissue wasting through a narrative and conceptual review, without assuming equivalence between Ayurvedic and biomedical concepts. **Discussion:** Ayurvedic descriptions of *Kṣaya/Rajayakṣma* emphasize progressive tissue depletion, while contemporary literature describes TB-associated wasting as a complex process involving inflammation, altered metabolism, undernutrition, and loss of lean tissue. *Dhatupaka* may therefore be considered a process-oriented concept

alongside *Dhatu-kṣaya*, which represents tissue depletion. **Conclusion:** *Dhatupaka* may offer a useful conceptual perspective on the progressive nature of tissue wasting in TB. However, its relationship with contemporary pathophysiological mechanisms remains hypothetical and requires further translational investigation.

KEYWORDS: *Dhatupaka*, *Rajayakshma*, *Kshaya*, tuberculosis, cachexia, integrative medicine

1. INTRODUCTION

Tuberculosis (TB) remains the world's leading infectious cause of death: an estimated 10.7 million people fell ill and 1.23 million died of TB in 2024 alone.[1] Long before the causative organism was identified, TB was recognized by its characteristic wasting, historically described as "consumption." Progressive weight loss, weakness, and tissue depletion were major features of the disease.[2] Wasting is not merely a consequence of infection; Undernutrition and TB are closely linked, with undernutrition increasing the risk of progression from TB infection to active disease.[3,4] Active TB itself produces a hypercatabolic, inflammation-driven state that worsens malnutrition, a pattern repeatedly described as a "vicious cycle."[5,6,7]

Ayurveda described a comparable wasting syndrome through *Rajayakshma*, characterized by progressive *Kshaya* (tissue depletion) and, in advanced stages, depletion of *Ojas*.[8,9] Existing Ayurveda–TB literature has mainly focused on *Rajayakshma* and *Dhatu-kshaya*, highlighting shared clinical features and therapeutic approaches.[10,11] In contrast, *Dhatupaka* has been less explored as a potential process contributing to tissue depletion, rather than merely representing its outcome.

This review examines the relevance of *Dhatupaka* to TB-associated tissue wasting, while distinguishing classical concepts, modern evidence, and conceptual interpretation without implying direct equivalence.

2. Concept of *Dhatpaka*

Dhatupaka (pathological tissue depletion) combines *Dhatu* (the seven bodily tissues)-*Rasa, Rakta, Mamsa, Meda, Asthi, Majja* and *Shukra*-with *Paka*, meaning transformation or processing. In Ayurvedic physiology, nutrients derived from digested food are progressively transformed into the Dhatus through their respective *Dhatvagni*.[8,9] Classical interpretations

describe different models of Dhatu formation, including sequential, simultaneous and selective transformation.[12] In this physiological context, *Dhatupaka* represents normal tissue formation and maturation.

A pathological interpretation of *Dhatupaka* is described mainly in diagnostic and prognostic literature. In this context, it refers to tissue-level damage or destruction and is distinguished from *Dosapaka*, which denotes the transformation or resolution of vitiated Doshas and may indicate a favourable stage of disease.[12] Thus, while *Doshapaka* suggests resolution of the pathological process, pathological *Dhatupaka* indicates progression towards tissue damage.

Unlike *Rajayakshma* and *Dhatu-kshaya*, *Dhatupaka* does not have a dedicated treatment or disease chapter in the *Brhat-trayi*. Its pathological usage is more prominent in later prognostic and secondary literature.[7,12] Therefore, it is better regarded as a comparatively underdeveloped concept within the broader *Agni–Dhatvagni–Dhatu* framework rather than as a distinct classical disease construct.

Within this framework, impaired *Dhatvagni* is considered to affect the formation and maintenance of *Dhatus*, with consequent effects on *Bala* and *Ojas.*[7,13] This perspective provides a basis for examining *Dhatupaka* not simply as tissue depletion, but as a possible process associated with progressive tissue deterioration in conditions such as TB-associated wasting.

3. *Kṣhaya* and *Rajayakṣhama*: Tissue Depletion

Kṣhaya, used broadly in Ayurveda for diminution of any bodily constituent, is refined in the context of tissue pathology into *Dhatu-kṣhaya*: the progressive loss of one or more *Dhatu*, most classically discussed for *Rasa* and, in advanced disease, *Maṃsa* and *Ojas.*[7,8] *Dhatu-kṣhaya* is not itself a single disease but a pathological state - progressive tissue depletion within the broader Ayurvedic pathology of obstruction, excess and deficiency.

Rajayakṣhma, described in a dedicated chapter of the *Chikitsa Sthana*, is the clinical syndrome in which this depletion becomes generalised and progressive.[7] *Charaka* distinguishes an intermediate stage, *Shoṣha*,, characterised by four causative patterns-excessive physical strain (Sahasa), suppression of natural urges (*Vega-sandharaṇa*), *Kṣhaya* proper, and irregular or incompatible dietary habits (*Viṣamasana*)-which, left unaddressed, progresses to full Rajayakṣhama.[8] The disease is traditionally described through eleven signs

(*Ekadasa-rupa*) spanning respiratory, gastrointestinal and constitutional domains, with pathogenesis involving vitiation of all three *Doṣha* acting on the *Praṇavaha*, *Annavaha* and *Rasavaha Srotas*, and progressive depletion moving through the *Dhatu* sequence toward *Ojas*.[7]

It is this final step-depletion reaching *Ojas*, the most subtle product of complete *Dhatu* formation-that classical texts link to loss of *Bala* and heightened vulnerability, a state broadly analogous in function, though not in mechanism, to compromised host resistance.[7,13] Contemporary reviews correlating *Rajayakṣma* with pulmonary tuberculosis have generally treated *Dhatu-kṣhaya* as the pathogenetic backbone of the correlation, since progressive tissue depletion is described as initiating and perpetuating the disease process.[9,10] This review accepts that framing but argues *Dhatu-kṣhaya* alone describes the endpoint-tissue already lost-more fully than the process by which loss occurs, a gap for which *Dhatupaka* may be conceptually better suited. For clarity, this review therefore treats *Kṣhaya* as the general phenomenon of depletion, *Dhatu-kṣhaya* as its manifestation at specific tissues, and *Rajayakṣma* as the generalised clinical syndrome resulting when depletion becomes systemic and self-perpetuating.

4. Tuberculosis and Tissue Wasting

Undernutrition is now recognised as the single largest population-level driver of TB, with a greater attributable burden than HIV, diabetes, alcohol-use disorder or smoking.[2] An updated dose-response meta-analysis spanning more than 24 million person-years confirmed a steep, non-linear inverse relationship between body mass index and TB risk, with risk rising sharply below a BMI of 25 kg/m² and an estimated roughly five-fold increase in risk associated with undernutrition (BMI < 18.5 kg/m²).[2] This relationship is bidirectional: undernutrition predisposes to progression from infection to active disease, while active TB itself drives further nutritional deterioration, delayed treatment response and higher mortality.[4,5,6] WHO clinical guidance now formally recognises this bidirectional causal link, identifying nutritional assessment and management as an integral, not merely adjunctive, component of TB care.[14]

The mechanisms of TB-associated wasting are increasingly well characterised, though a recent scoping review spanning 44 studies and more than 16,500 individuals with TB concluded that TB-associated cachexia itself has not yet been clearly defined or phenotyped, and that mechanistic human data remain scarce relative to observational anthropometric

data.[15] What is established is that pulmonary TB is consistently associated with reduced skeletal muscle mass and function at diagnosis, that low muscle mass at diagnosis predicts mortality, and that muscle mass recovers only partially with treatment-with weight regained during treatment disproportionately reflecting fat rather than muscle accretion.[15]

Mechanistically, TB-associated wasting is increasingly understood as an active, inflammation-driven catabolic process rather than a passive consequence of reduced intake. Mycobacterium tuberculosis reprogrammes macrophage metabolism toward a glycolytic, HIF-1α-driven state, generating elevated systemic pro-inflammatory cytokines-principally TNF-α, IL-6 and IL-1β that act on skeletal muscle to activate the ubiquitin–proteasome system and autophagy–lysosome pathway, suppress mTOR-dependent protein synthesis, and impair mitochondrial function, together producing net muscle protein loss.[16] This immunometabolic catabolic state operates alongside anorexia, malabsorption and increased energy expenditure, producing the combined lean- and fat-mass depletion long recognised clinically as TB-associated wasting.[3,4,5]

5. The Possible Role of *Dhatupaka* in Tissue Wasting

The preceding sections establish two sequences independently: an Ayurvedic sequence — *Doṣha* disturbance, *Agni*/*Dhatvagni* dysfunction, pathological *Dhatupaka*, *Dhatu-kṣhaya*, and eventual *Bala*/*Ojas* depletion — culminating in *Rajayakṣhama*, and a biomedical sequence-macrophage immunometabolic reprogramming, systemic cytokine release, muscle proteolysis-culminating in TB-associated cachexia. Taken together, these observations suggest that the two sequences, while operating at entirely different explanatory levels, share a structurally similar shape: both describe a staged progression from an initiating disturbance, through a metabolic derangement at the tissue level, to depletion of structural tissue, to loss of systemic functional reserve.

On this basis, a conceptual sequence is proposed: chronic disease burden / *Doṣha* disturbance → *Agni* and *Dhatvagni* dysfunction → *Dhatupaka* (abnormal tissue-level transformation) → progressive *Dhatu-kṣhaya* → *Bala* and *Ojas* deterioration → clinical wasting, weakness and reduced physiological resilience. Three distinct epistemic layers should be kept explicit within this sequence, because collapsing them would overstate the correlation. What is directly supported by classical texts is that *Rajayakṣhama* arises through Doṣa vitiation and progressive *Dhatu* depletion culminating in *Ojas* loss, and that *Dhatupaka*, in its pathological usage, denotes destructive tissue-level change associated with poor prognosis.[7,8,12] What is

supported by modern biomedical evidence is that TB produces a cytokine-mediated catabolic state that degrades muscle protein through defined molecular pathways, alongside undernutrition in a bidirectional, self-reinforcing relationship[4,15,16] Distinct from both is the authors' conceptual synthesis: the proposal that *Dhatupaka* — because it names the process of pathological transformation rather than merely its endpoint — offers a more apt point of phenomenological correspondence with the active, mechanistically driven catabolic process now described in TB than *Dhatu-kṣhaya* alone, which corresponds more naturally to the resulting state of depletion than to the process generating it.

Rather than equating *Dhatupaka* with any single biomedical mechanism such as ubiquitin–proteasome-mediated proteolysis, it may be more appropriate to view *Dhatupaka* as a systems-level placeholder within Ayurvedic physiology for "tissue being actively broken down by disease," occupying a structurally analogous-though not mechanistically equivalent-position to the modern description of an inflammation-driven catabolic state that actively degrades tissue rather than merely failing to sustain it. From an Ayurvedic perspective, this may be interpreted as reframing wasting as an active process with its own pathological trajectory, distinct from the passive framing implied by "malnutrition" alone-a reframing that happens to converge, descriptively, with the current biomedical shift away from viewing TB-associated weight loss as simple undernutrition and toward viewing it as active, immunometabolically driven cachexia.[15,16] This interpretation generates a testable hypothesis, addressed in Section 9: that clinical or biochemical correlates of "active" tissue catabolism in TB may correspond more closely to states an Ayurvedic clinical assessment would characterise as *Dhatupaka*-dominant than to simple *Dhatu-kṣhaya* — though this remains speculative and unvalidated.

6. Understanding the Clinical Expression of Tissue Wasting

Table 1 summarises the correlations proposed above, with an explicit indication of the strength and type of correlation asserted for each. None of these correlations should be read as claims of mechanistic identity; each represents, at most, a conceptual or phenotypic correspondence useful for generating hypotheses, requiring independent empirical validation before any translational application.

Table 1: Proposed Ayurvedic–modern conceptual correlations in TB-associated tissue wasting.

Ayurvedic concept	Possible modern correlate	Strength / type of correlation
Doṣha disturbance / chronic disease burden	Chronic infective and inflammatory stimulus (M. tuberculosis infection)	Conceptual
Agni / *Dhatvagni* dysfunction	Altered systemic and tissue-level energy metabolism	Conceptual
Dhatupaka (pathological tissue transformation)	Cytokine-driven catabolism (ubiquitin–proteasome and autophagy–lysosome-mediated proteolysis)	Hypothesis / analogy
Dhatu-kṣhaya	Loss of skeletal muscle and adipose tissue (fat-free and fat mass)	Phenotypic correlation
Bala-kṣhaya	Reduced physical function and muscle strength	Phenotypic correlation
Oja-kṣhaya	Reduced systemic resilience / immune competence	Conceptual, not equivalence
Kṣhaya / *Rajayakṣma*	TB-associated wasting / cachexia phenotype	Clinical / phenotypic correlation

7. Implications of the *Dhatupaka* Perspective for *Kṣhaya* and Tuberculosis

Building on Section 5, TB-associated wasting can be conceptually organised through three interacting levels drawn from Ayurvedic physiology, each mapped-cautiously-onto a corresponding modern process. At the Agni level, chronic mycobacterial infection and its inflammatory burden may be conceptually likened to a sustained disturbance of digestive and metabolic fire, corresponding to the altered energy expenditure, anorexia and impaired nutrient utilisation documented in TB.[3,4] At the *Dhatu* level, the proposed *Dhatupaka–Dhatu-kṣhaya* sequence provides a staged description of tissue transformation giving way to depletion, corresponding to the cytokine-mediated muscle proteolysis and progressive lean- and fat-mass loss described in recent immunometabolic reviews.[15,16] At the systemic level, progressive reduction in Bala and Ojas corresponds descriptively to the loss of physical function and muscle strength observed in TB-associated cachexia, including the association between low muscle mass at diagnosis and increased mortality.[15]

This three-level model is not intended to replace modern mechanistic accounts of TB-associated cachexia, which are considerably more granular and empirically grounded than the Ayurvedic framework can currently offer. Its proposed value is complementary: a compact, clinically oriented vocabulary for describing the whole-person trajectory of wasting-from

disturbed metabolism, through active tissue breakdown, to systemic functional decline-that may be useful for framing patient assessment or research questions in integrative settings, without displacing the biomedical evidence base that should continue to guide diagnosis and treatment.

8. Critical Appraisal and Limitations

Several limitations temper the framework proposed here. First, *Dhatupaka* is a constitutional and prognostic construct developed within a pre-modern epistemological system organised around *Doṣha*, *Dhatu* and *Agni*; it was not formulated to describe, and cannot be assumed to anticipate, cytokine biology, proteasomal degradation or mitochondrial dysfunction. Any structural correspondence proposed in Sections 5–7 is phenomenological, not mechanistic, and should not be read as claiming that classical authors described modern TB pathophysiology in disguised form.

Second, as noted in Section 2, *Dhatupaka* itself is comparatively underdeveloped in the primary *Bṛhat-trayi* relative to *Dhatu-kṣhaya* and *Rajayakṣma*; its clearest textual elaboration is prognostic rather than pathogenetic, and much of its systematic articulation is the work of later *nidana* literature and contemporary Ayurvedic scholarship rather than a dedicated classical treatise.[12] This review's central proposal — using *Dhatupaka* as a process-level framework for wasting rather than a prognostic sign — is therefore an extension of the classical material, not a restatement of it, and should be labelled explicitly as the authors' interpretation rather than settled Ayurvedic doctrine.

Third, no published study, to the authors' knowledge, has measured *Dhatupaka*, *Dhatu-kṣhaya* or *Ojas* depletion using validated clinical instruments alongside objective TB-wasting biomarkers-body composition, inflammatory markers, muscle function-in the same cohort. The correlations proposed in Table 1 are hypotheses awaiting empirical testing, not findings.
Fourth, the modern literature on TB-associated cachexia is itself still maturing: a recent scoping review explicitly noted that TB-cachexia has not been consistently defined or phenotyped and that mechanistic human data remain limited relative to anthropometric observation.[15] A correlative framework built partly on this evolving evidence base should be regarded as provisional and open to revision as biomedical understanding develops.

Finally, this review has not addressed Ayurvedic therapeutics; existing evidence for adjunctive Ayurvedic treatment in TB remains limited in quality and scope, and nothing in this conceptual framework should be taken to imply a treatment recommendation.[9,10]

9. Future Research Directions

Several specific research questions follow from this framework. Can validated Ayurvedic clinical assessment of *Dhatu-kṣhaya* and Ojas status be correlated, in a prospective TB cohort, with objective measures of body composition (bioelectrical impedance or DXA-derived fat-free mass), grip strength, and inflammatory markers (CRP, IL-6, TNF-α) at diagnosis and through treatment. Can a distinction be operationalised between a "*Dhatupaka*-dominant" clinical presentation — characterised by rapid, inflammation-associated lean-mass loss-and a more indolent, primarily nutritional pattern of depletion, and if so, do these patterns predict differential response to nutritional supplementation, as suggested by the mixed results of macronutrient trials in TB.[15] Can longitudinal Ayurvedic assessment across TB treatment track whether recovery of Bala and reduction in *Dhatu-kṣhaya* severity parallel the partial, fat-predominant recovery of body composition documented in recent cohorts.[15]

Finally, can *Dhatupaka* be operationalised into a measurable clinical domain-for instance, a structured symptom and sign checklist derived from classical *Sadhya-asadhyatva* criteria — without distorting or oversimplifying the construct as originally described.[12] Each of these questions requires dedicated, adequately powered translational studies; none can be answered by conceptual analysis alone.

10. CONCLUSION

This review has examined whether *Dhatupaka* can serve as a useful conceptual framework for understanding the progressive tissue depletion of *Kṣhaya*/*Rajayakṣhama*, with particular reference to tuberculosis-associated wasting. Read on its own terms, *Dhatupaka* names the process of pathological tissue transformation that precedes and generates *Dhatu-kṣhaya*, and this process-level framing offers a phenomenological parallel-not an equivalence-with the active, inflammation-driven catabolic cascade increasingly documented in TB-associated cachexia. The correlations proposed here, summarised in the conceptual model and correlative table above, are interpretive syntheses intended to generate testable hypotheses, not established findings. Whether *Dhatupaka* can be operationalised as a clinically or biochemically measurable construct, and whether doing so adds explanatory or translational

value beyond existing biomedical models of TB cachexia, remains to be determined through dedicated empirical and translational research.

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