LITERATURE REVIEW

The Clinical Use of Monolaurin as a Dietary Supplement: A Review of the Literature

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ABSTRACT

Objective: The purpose of this study was to determine what the peer-reviewed literature says about the clinical applications, therapeutic dosages, bioavailability, efficacy, and safety of monolaurin as a dietary supplement.
Methods: This was a narrative review using the PubMed database and the terms "monolaurin" and its chemical synonyms. Commercial websites that sell monolaurin were also searched for pertinent references. The reference sections of the newer articles were searched for any other relevant articles. Consensus was reached among the authors as to what articles had clinical relevance.
Results: Twenty-eight articles were found that appeared to address the clinical use of monolaurin.
Conclusion: There are many articles that address the antimicrobial effects of monolaurin in vitro. Only 3 peer-reviewed papers that evidence in vivo antimicrobial effects of monolaurin in humans were located, and these were only for intravaginal and intraoral—that is, topical—use. No peer-reviewed evidence was found for the clinical use of monolaurin as a human dietary supplement other than as a nutrient. (J Chiropr Med 2019;18;305-310)
Key Indexing Terms: *Anti-Bacterial Agents; Antiviral Agents*

INTRODUCTION

Monolaurin first became available as a nutritional formulation in the mid-1960s and today is sold worldwide as a nutritional supplement that is touted as a support for immune system function, healthy balance of intestinal flora, and beneficial levels of yeast.[1] Its use has been associated with a variety of disorders, including the common cold, influenza, swine flu, herpes simplex, shingles, and chronic fatigue syndrome.[2]

Monolaurin—very commonly known by 1 of its chemical names, glycerol monolaurate (GML)—is the monoester formed from glycerol and lauric acid. Lauric acid is a naturally occurring 12-carbon medium-chain saturated fatty acid. The richest dietary source of GML is coconut oil.[3] GML is also found in human breast milk[4] and palm kernel oil.[5] Although the body can convert lauric acid into GML by enzymatic activity, it is not known how much this process actually occurs in vivo.[6]

Because GML is a surfactant, it has been used for decades as a dispersant and emulsifier in the cosmetics industry and as a food additive in the food industry, acting as an emulsifier and preservative.[7] The antimicrobial activity of fatty acids and their esters is well known, with chain length, unsaturation (*cis*, *trans*), and functional groups all being variables that affect this activity.[8] This antimicrobial activity appears mainly to be by disruption of lipid bilayers.[9] GML is 1 of the more potent of these antimicrobial agents, being up to 200 times more effectual than lauric acid in bactericidal activity against certain microbes in in vitro studies.[10] It may have been this potent antimicrobial activity that led some to explore its potential clinical use as a nutritional supplement.

Some supplement companies and health practitioners recommend gradually increasing the oral daily adult dose up to 1 to 5 grams of GML (less in children).[11,12] One vendor, quoted by several commercial websites, endorses up to 9 g of GML daily as an adult maintenance dose.[1] The Food and Drug Administration (FDA) has granted GML the status of generally recognized as safe[13] but has published no standard dosing guidelines.[6] The stability[14] and solubility[15] of GML are low in an aqueous environment, and the FDA has stated that topical application of GML is safe up to concentrations of 100 mg/mL.[16]

There seems to be a fairly large amount of anecdotal reporting that GML as a dietary supplement has a range of

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positive applications for human health and disease prevention.[1,2] The purpose of this study was to determine what evidence there is in the peer-reviewed literature about the clinical applications, therapeutic dosages, bioavailability, efficacy, and safety of GML as a dietary supplement.

Methods

This was a narrative review. Use of review protocols was somewhat limited by the nature of the GML literature. We performed a Boolean search of PubMed (from the beginning of its indexing through April 2018) using the following terms: monolaurin OR glycerol monolaurate OR glyceryl laurate OR 1-lauroyl-glycerol. From this list of citations, the authors individually reviewed the associated abstracts for clinical relevance—that is, whether they contained information related to the clinical applications, therapeutic dosages, bioavailability, efficacy, or safety of GML as a dietary supplement—and then, after discussion, came to consensus on which of these references had such clinical relevance. The full articles for these abstracts were obtained. The reference sections of newer articles were searched for any other pertinent articles. Also, commercial websites that sell GML as a dietary supplement were searched for articles that they cited as evidence for the use of GML. Consensus was reached among the authors as to which articles would be included. Only articles in English were used for this study. Given the paucity of articles and total lack of human clinical trials, no research designs were excluded. There was no quality assessment used, since most of the studies were very simple, straightforward, basic research designs. No clinical entities were excluded.

Results

The PubMed search yielded 190 articles, none of which were human clinical trials using GML as a nutritional supplement. Many of the citations dealt with food preparation or storage issues. After reviewing the abstracts of all 190 articles and searching the reference sections of newer citations and commercial websites for further articles and eliminating duplicates, the authors reached consensus on 28 sources that seemed to address either clinical uses of GML or issues that could have clinical implications.[4,8,10,14,16-39]

Discussion

The antibacterial activity of GML in vitro is well documented. In broths, a nutrient-rich substrate inoculated with pathogens, GML is effective against a wide range of gram-positive, gram-negative, and acid-fast organisms (Table 1).[8,10,17] The effectiveness is influenced by pH,

Table 1. *Antibacterial Activity of Monolaurin (Glycerol Monolaurate)*

Bacterium	Gram or Other Stain
Staphylococcus aureus	Positive
Streptococcus pyogenes	Positive
Streptococcus agalactiae	Positive
Group C *Streptococcus*	Positive
Group F *Streptococcus*	Positive
Group G *Streptococcus*	Positive
Streptococcus suis	Positive
Streptococcus sanguinis	Positive
Streptococcus pneumoniae serotype 3	Positive
Enterococcus faecalis	Positive
Listeria monocytogenes	Positive
Bacillus anthracis Sterne	Positive
Bacillus cereus	Positive
Peptostreptococcus species	Positive
Clostridium perfringens	Positive
Neisseria gonorrhoeae	Negative
Haemophilus influenzae nontypeable	Negative
Gardnerella vaginalis	Negative
Campylobacter jejuni	Negative
Bordetella bronchiseptica	Negative
Burkholderia cenocepacia	Negative
Pasteurella multocida	Negative
Prevotella melaninogenica	Negative
Bacteroides fragilis	Negative
Fusobacterium species	Negative
Pseudomonas aeruginosa	Negative
Acinetobacter baumannii	Negative
Mycobacterium phlei	Acid fast
Mycobacterium tuberculosis	Acid fast
Mycoplasma hominis	Cell-wall deficient

Table 2. *Bacteria Not Susceptible to Monolaurin (Glycerol Monolaurate)*

Bacterium	Gram Stain
Escherichia coli	Negative
Salmonella minnesota	Negative
Klebsiella aerogenes	Negative
Proteus vulgaris	Negative
Shigella sonnei	Negative
Klebsiella pneumoniae	Negative

temperature, the biochemical nature of the fatty acid, and any binding agent.[8,10] On the other hand, several other commonly pathogenic gram-negative strains of bacteria do not appear to be affected by GML (Table 2).[10]

GML is also effective against several bacterial biofilms, including those produced by *Staphylococcus aureus, Enterococcus faecalis, Pseudomonas aeruginosa*, and *Acinetobacter baumannii.*[10,17,18] Surgical incisions in rabbits inoculated with *S. aureus, P. aeruginosa,* or *A. baumannii* were painted with a carrier gel alone or with GML. The GML gel reduced the bacterial count measured in colony-forming units and the inflammatory redness at the infected site compared to carrier gel alone.[17] In women, tampons with GML have been shown to reduce vaginal *S. aureus* colony-forming units compared to tampons without GML.[19] And it has been shown that GML loaded in a microemulsion has enhanced antimicrobial activity compared to GML alone.[14]

At concentrations below those that are bacteriocidal, GML can inhibit the production and the effects of several gram-positive bacterial toxins in vitro. These include staphylococcal enterotoxins, toxic shock syndrome toxin 1 (TSST-1), anthrax toxin, and several hemolysins.[20-21] Intravaginal application of GML in an in vivo rabbit model decreases the lethality of TSST-1 apparently by stabilizing the host cell membranes and blocking signal transduction.[22] In women, tampons with GML reduce vaginal TSST-1 and production of the cytokine interleukin-8 compared with tampons without GML.[19] GML can furthermore inhibit lipase production by *S. aureus* and *Staphylococcus epidermidis* at concentrations that do not adversely affect the growth of these commensal ocular bacteria in an in vitro model.[16]

GML appears to increase the effectiveness of certain other antibacterial agents in vitro. For example, the addition of GML to menaquinone analogues,[23] ethylenediaminetetraacetic acid (EDTA),[10] and origanum oil[24] appears to enhance their ability to inhibit the growth of *S. aureus*. Incorporation of AP114 and AP138, antimicrobial peptides derived from plectasin, into monolaurin-lipid nanocapsules has displayed synergistic effects against *S. aureus*, including methicillin-resistant *S. aureus*.[25] Likewise, the combination of GML and *cis*-2-decenoic acid expresses synergistic antispirochetal (*Borrelia* sp) effects, including on biofilms.[26] In a human in vivo study, rinsing with a mouthwash containing lysine and GML decreases oral *Helicobacter pylori* infection better than the traditional treatment of teeth cleaning.[27] This increased the success rate of eradication of a concurrent gastric *H. pylori* infection in the population studied.

There are in vitro studies that have shown that GML has antiviral activity against HIV-1, herpes simplex virus (HSV) −2,[28] and cytomegalovirus, but not human rhinovirus 2.[4] An in vivo monkey study has shown that daily use of intravaginal GML protected against occult infection from repeated high doses of simian immunodeficiency virus, the rhesus macaque model of HIV-1.[29] Intravaginal GML appears to increase susceptibility to HSV-2 in a mouse model,[30] but these findings may be inconclusive for a human model, as epithelial thickness differs.[28] A vaginal cream with up to 35% GML has no effect on vaginal flora and cytokine (MIP-3 and IL-8P) levels in rhesus macaques.[31] On the other hand, it has been shown in an in vitro model of the female primate genital mucosa that a vaginal microbicide preparation containing GML caused cell death and disruption of the epithelial barrier at concentrations near its active in vivo concentration, which may actually increase the possibility of infection by such organisms as HIV-1.[32]

GML has shown in vitro antifungal activity to *Candida albicans* in biofilms.[33] There is also both in vitro and in vivo evidence in women that intravaginal gels containing GML reduce counts of several *Candida* species and *Gardnerella vaginalis*, although control gels also reduce *G. vaginalis* counts. Neither of these gels affects *Lactobacillus* counts or alters vaginal pH.[34]

Some evidence exists for possible intravaginal and intraoral—that is, topical—antimicrobial applications for GML clinically in humans, but is there any evidence for internal, including dietary or supplemental, clinical benefits? One study using an in vivo subcutaneous rabbit model has shown that GML is bacteriocidal to *S. aureus* and decreases TSST-1 production.[21] It has also been established that the lipid fraction of stomach aspirates from premature infants 1 hour after feeding with human milk or standard cow-milk infant formulas reduces counts of *S. epidermidis*, *Escherichia coli*, HSV-1, and vesicular stomatitis virus.[35] All these milks contain about 40% to 50% medium-chain triglycerides, but they were not analyzed for individual fatty-acid content. It was shown that lipase activity is necessary for this effect, indicating that it was fatty acids that were the active microbicidal agents. Although this evidence points to the antimicrobial activity of a variety of ingested lipids, it does show that these retain their antimicrobial activity in the digestive tract, at least to the level of the stomach. Because GML is found in human milk, one could infer that it was most likely present in

the milks and as a degradation fatty-acid product in the stomach.

One small in vivo study was found that directly addresses the microbicidal action of GML when administered orally through a feeding tube directly into the stomach. Mice weighing 20 g were infected with *S. aureus* at 5 times the median lethal dose. Fifty percent (4 of 8) of the animals survived for 30 days after receiving a daily gavage of 3.2 mg of GML for 10 days.[24] The same number (4 of 8) survived who received the antibiotic vancomycin. No animal in either the untreated group (0 of 8) or the olive oil−only control group (0 of 8) survived for 30 days. A similar dosage of GML adjusted for a 70-kg human would be about 11 g.

There are a variety of other effects that may have clinical implication for GML. Topically, it is a spermicide, reducing both the motility and viability of sperm in the vaginal tract.[28,35] Unfortunately, therapeutic indices comparing polarized epithelial cell toxicity with sperm toxicity for several surfactants, including GML, in vitro do not justify their use as contraceptive agents.[36] There is in vitro evidence that GML has a dose-dependent effect on T-lymphocyte activation and proliferation, which may suggest its use in immune system support.[37] On the other hand, it appears that human serum albumin, one of the most abundant proteins in human blood, potently reverses the suppression of human T-lymphocytes by GML in vitro.[38] In mice with peritoneally implanted tumor cells of Ehrlich carcinoma, injected GML saline solutions inhibit tumor growth.[39]

We could find no peer-reviewed evidence regarding human clinical applications, therapeutic dosages, bioavailability, efficacy, or safety of GML as a dietary supplement other than the "generally recognized as safe" status granted by the FDA.

Limitations

Because there were not very many studies addressing the clinical use of GML, and none of these are human clinical trials using GML as a nutritional supplement, the present study was a narrative, not a systematic, review. Standard systematic review protocols were used as much as possible given the nature of the literature, but they could not be strictly followed. It is therefore possible that salient studies were missed. This is unlikely, though, because commercial enterprises vending GML as a dietary supplement are highly motivated to support their product with peer-reviewed research.

Conclusion

There are only 3 peer-reviewed articles showing evidence for in vivo antimicrobial effects of GML in humans, and these were only for intravaginal (tampon) and intraoral (mouthwash)—that is, topical—use. No peer-reviewed evidence for the human clinical use of GML as a dietary supplement was found, other than as an ester of a medium-chain fatty acid. Given the large amount of anecdotal evidence that supplemental GML in the diet can have many positive clinical effects, there appears to be a critical need for the scientific community to address these claims.

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No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): L.A.B.
Design (planned the methods to generate the results): L.A.B., B.W.B., C.C.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): B.W.B.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): B.W.B.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): L.A.B., B.W.B., C.C.
Literature search (performed the literature search): B.W.B.
Writing (responsible for writing a substantive part of the manuscript): L.A.B., B.W.B.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): L.A.B., B.W.B., C.C.

Practical Applications

- Although there is anecdotal evidence, we could find no peer-reviewed research regarding human clinical applications, therapeutic dosages, bioavailability, efficacy, or safety of monolaurin as a dietary supplement, other than the "generally recognized as safe" status granted by the Food and Drug Administration.

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