THE BEST VEGETABLE OIL FOR PRETERM AND TERM INFANT MASSAGE

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Abstract

Although is incompletely developed, in a full process of maturation for months after birth, neonatal skin has important developmental roles and in preventing morbidity. Ancient practice, oil massage of the infant has multiple benefits but recent studies are demonstrating that not all oils are suitable for infant massage. The paper is reviewing the neonatal skin characteristics and functions, the benefits of oil massage, and the role of emolients in neonatal skin care, presenting the the effect of different vegetable oils used for preterm and term infants' massage. Composition of vegetable oils must be known before recommending or using a certain vegetable oil for infant massage, since not "everything natural is good or safe for children". More studies are needed to establish the biological value of the vegetable oils in neonates, to clearly delineate which vegetable oil is the best in terms of efficiency and safety for infant massage.

Keywords: neonatal skin, vegetable oil, oil massage, sunflower oil, preterm infant

Introduction

The neonatal skin is structurally and functionally immature both in preterm and term infants and has multiple protective roles, having an important role for morbidity and mortality prevention in infants. Therefore, neonatal skin care must address these important characteristics of the neonatal skin and limited cutaneous skin barrier functionality, aiming to maintain skin integrity, to avoid exposure to harmful chemical agents, and to prevent toxicity.

Purpose

The aim of the paper was to review the scientific proofs regarding the best option for oil massage of the newborn.

Material and method

The authors reviewed the published literature regarding neonatal skin maturity and function in preterm and term infants and use of oil massage for neonatal skin care. The use of emolients and vegetable oils for massaging preterm and term neonates was also reviewed as regards effects and recent controversies related to vegetable oils content as these aspects are less known for clinicians and different fatty acid content may have beneficial or harmful effects on the neonatal skin. The search for relevant papers used the major databases and search engines on medicine, biomedicine, chemistry, and multidisciplinary (as for example Pubmed, Medline Plus, Pubchem, Scopus).

Results

A. The neonatal skin

The skin is a complex, dynamic organ with multiple vital functions: physical barrier between the body and environment, body temperature regulation, immunity and protection against pathogen invasion and ultraviolet radiation, gas exchanges, sensorial perception. (1-8). Development of the aqueous barrier of the skin begins during the first trimester of the pregnancy and is finalized by 34 weeks of gestation. (2,8-10), maturation of the epidermal cells continues during the entire pregnancy while the corneous stratum and the dermal-epidermal undulations are seen at 34 weeks gestation when the cutaneous barrier maturation is almost complete. (9,11-14) Even in term infants, with a normal functioning of the cutaneous barrier, an increased tendency to irritation and allergic dermatitis is described, presumably due to increased percutaneous absorption and an incompletely developed functionality. (15,16)

Cutaneous barrier functionality is also influenced by the environment and by the dramatic changes occurring during transition from the aqueous intrauterine environment to the colder, drier, and extremely variable extrauterine environment. Initial studies suggested that functional adaptation of the skin to adult functionality takes weeks to months (17) but recent studies demonstrated that maturation may take up to 12 months. (9,18-21) Therefore, the neonatal skin is very sensible, thin, and fragile, prone to increased transepidermal water loss, abnormalities of the fluid and electrolytes homeostasis, excessive bacterial proliferation, vulnerable to trauma, and increased sistemic toxicity (due to increased absorption of chemicals applied on the skin, increased body surface/body weight ratio, and immature systems for drug metabolization). (2,4,13,22-26)

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A thinner skin, with weaker cohesion between dermis and epidermis, increased vascularization, and a less efficient skin barrier are mounting all this risks in the preterm infant (4,27) suggesting that efficiency of the cutaneous barrier functionality is critical for decreasing the neonatal morbidity and mortality, especially in low birth infants. (4,5,28,29) The skin of the preterm infant is comparable with the term infant's skin only 2-3 weeks after birth. (2,30) There are studies showing that during the late neonatal period 50% of the neonatal deaths are related to infections and an incompetent skin barrier is the major predisposing factor for neonatal sepsis. (31,32)

The main factors supporting the neonatal cutaneous skin barrier function are: a more neutral skin pH - protecting against infections and water loss (4,5,8,22) -, epidermal lipids - important for maintaining the skin integrity but with lower concentrations in newborns due to decreased activity of the sebum producing glands and increased water content of the skin (4), natural emolient factors of the stratum corneous - acting as lubricating agents (9) -, and antimicrobial peptides produced by keratinocytes (5) -. Another important factor to consider in neonates is the unique adaptive flexibility of the cutaneous barrier allowing optimization of the growth and skin development, thermal regulation, transepidermal water loss, and protective mechanisms. (2,8,21)

Neonatal skin care must address these important characteristics of the neonatal skin and limited cutaneous skin barrier functionality, aiming to maintain skin integrity, to avoid exposure to harmful chemical agents, and to prevent toxicity.

B. Massage during neonatal period

During the last two decades a great emphasis was put, in neonatology, on developmental care of the preterm infant. Touch is recognized as one of the principle of the developmental care (33) therefore massage of the newborn, especially of the preterm infant, was more and more integrated in this modern type of care, in neonatal units and at home. Moderate pressure massage, by kinesthetic tactile stimulation, stimulates infant growth and development (34-37), brain development, reduces the stress level, and decreases the risk for retinopathy of prematurity (38,39).

C. Oil massage during neonatal period

First introduced in China, in the 2nd century B.C. (40), oil infant massage is a routine practice in many of the countries of the Indian subcontinent and Mediterranean area. (5,41,42) Studies performed in the latest years have undoubtedly demonstrated numerous benefits of the neonatal oil massage: improved skin status and prevention of cutaneous lesions (25,28,42), improved thermoregulation (25,41), increased weight gain (due to increased vagal activity, improved gastric motility, increased level of insulin-like growth factor 1 (10,37), and by preserving warmth and energy (43)) (44-49), better sleep/arousal pattern (44-46)], improved sympathetic central nervous system development (44,45), decreased stress levels, better coordination of respiration with heart activity (50), improved motor and emotional development (46-49,51), increased oxygenation (52), decreased nosocomial infections and mortality rates (25,37,44-46,52,53), increased bone density (46), better skin nutrition (due to lipids absorption through the skin) (47,48), decreased hospitalization in the intensive care units (44,45), reduced hospitalization costs. (54) Most of these benefits are seen with simple massage but oil massage is more efficient. (55)]. Also, applying oils immediately after bath, on the wet skin is more efficient. (4) Compared to simple massage, oil massage is associated with decreased motor activity, decreased stress behaviors, increase vagal activity, and increased salivary cortisol level. (35,56) However, experts are cautioning against vigorous massage, even with oils, since it increases the risk for rashes, skin lesions, bacterial colonization, and infections. (28,41,55) Some of the adverse effects of the oil massage of the newborn are related to the used oils. (41)

Common name	Sistematic abreviation	Olive oil	Sunflower oil	Soy oil	Rapeseed oil	Sesame oil	Peanut oil
Palmitic acid	16:0	11.5; 12.22	6; 6.6; 7.31	10; 12.13; 5.80; 11.1	4; 3.36; 5.15; 3.73	8.5; 11.2; 10.2; 5.14	8.75; 10; 6.23; 14.1
Stearic acid	18:0	2.5	3.08; 5; 3.75	3.49; 5; 8.28; 5.6	1.5; 2; 1.66; 3.49;	4.5; 5.22; 5.42; 5.14	2.14; 3; 2.95; 2.7
Arahidic acid	20:0	0.5	0.5; -; -	0.5; -; -;-	0.5; 0.67; -; -	-; 0.5; -:-	1.05; 1.5; -; 1.6
Oleic acid	18:1(9)	74.37; 75.5	17.31; 23; 29.5	21; 23.41; 31.5; 22.6	61.6; 63; 65.3; 50.95	41.91; 42; 43.0; 39.65	41; 60.21; 68.49; 49.1
Linoleic acid	18:2(9,12)	7.5; 9.84,	63; 73.31; 59.2	53; 54.18; 45.00 ; 47.2	20; 20.38; 19.8; 39.75	40.08; 4.5; 41.1; 44.73	35.5; 21.28; 18.28; 27.4
Linolenic acid	18:3(9,12,15)	0.59; 1.0	<0.5; -; 0.07	0; 6.5; 5.49; 5.7	8.47; 9; 7.86; 0.34	0; -; 0.14; 0.56	0; 0.54; 0.05; -
References		(97,104)	(97,104,105)	(97,104,108,109)	(97,104,105,108)	(97,104,105,108)	(97,104,105)

Table 1. Reported fatty acid composition of some vegetal oils

Vegetable oil	Oleic acid	Linoleic acid	References
	18:1(9)	18:2(9,12)	
Mustard	9.26	13.79	(101)
Safflower	12.59; 12	77.54; 78	(97,104)
Corn	24.9; 39.65; 32.5; 27.5; 27.65; 28.6	33.6; 44.73; 52; 55.7; 57.21; 55.6	(97,103,104,108,111)
Wheat germs	17.42; 20; 14.36	56.72; 52; 61.62	(97,104)
Walnut	16.8; 16; 22.65, 28.3	58.35; 59; 55.13; 53.8	(97,103,104)
Pumpkin	36.5; 28.7; 24; 25.9;	44.46; 59.5; 54; 50.9,	(103,104,105)
Rice bran	40.4	36.1	(104)
Argan	45.1	34.2	(113)
Grapeseeds	62.26	6.22	(114)

Table 2. The oleic and linoleic acid content of some oil

D. Emolients during the neonatal period

Emolients are acting by softening the skin, establishing it's elasticity and homeostasis, lubricating and humidifying the skin, preventing transepidermal water loss, and preserving the skin integrity. (2,4,5,22,57) There are studies demonstrating also that emolients may prevent atopic dermatitis (4,58), nosocomial infections, and neonatal mortality. (59,60) On the surface of the skin, emolients are leaving a lipid film that fills the spaces between corneocytes, facilitating their adherence to the corneous stratum, humidifying and occlusive effects that prevent water loss. (61) Oils applied on the skin are offering lipids to keratinocytes, lipids that are transported by the cell membrane and metabolized into the cells (59) and used to build a functional epidermal barrier. (62) Oils must not be used in dermatoses, skin inflammatory lesions, and in flexure areas due to the occlusive effect. (4) Emolients that are not irritant for the skin, containing lipids known to improve skin barrier are recommended in preterm and term infants. (4,29,63) Some are recommending mineral oils on the maturing skin arguing that mineral oils are more stable, semi-occlusive, not miscible with water, and with longer term of validity. (5,64) Unfortunately, there are no long-term studies evaluating the use of emolients in the neonatal period. (5) A recent systematic review based on 8 studies developed in developing countries evaluating emolient use compared to routine skin care in the first 96 hours of life for a minimum of one week, in infants less than 37 weeks gestation, showed that emolients decreased the mortality rate by 27%, the infection rate by 50%, improved weight gain without significant impact on height and cranial circumference in the first month of life. (65) An even more recent meta-analysis of 18 eligible trials, comprising 3089 infants, evaluating topical emolients showed no difference as regards the rate of invasive infections (relative risk of 1.13 [95%CI 0.97-1.31]) and the mortality rate (relative risk of 0.8 [95%CI 0.5-1.03]). (66) Another meta-analysis, evaluated topical ointments effect against nosocomial infections, applied in the first 96 hours of life in 1304 preterm infants aged less than 37 weeks gestation and found that the procedure increased the risk of infections with coagulase-negative Staphylococcus, the risk for any infection, and for nosocomial infections (relative risks of 1.31, 1.19, and 1.20, respectively) but authors evaluated only 4 trials and speculate that the results may be due to contamination of the ointments and/or occlusive effect of the ointment delaying the skin maturation. (67)

E. Vegetable oils used for massaging newborns and preterm infants and their effects - current knowledge and controversies

Massage with vegetable oils in the neonatal period have demonstrated that some of them may increase the skin integrity and decrease the risk of dermatitis (57,68) but controversies related to efficiency in at risk neonates are persisting. Cutaneous and systemic benefits of the oils are based on the oil's composition (25), some of them having even toxic effects after skin absorption or delaying the healing of a compromised cutaneous barrier. Adverse effects are seen mostly in preterm infants. (25,41,42) Recent studies have shown that, applied on the skin, the oils are penetrating the corneous stratum and oils containing even low concentrations of oleic acid (over 25%) may disrupt the protective skin barrier, penetrate the dermis-epidermis junction, affecting it's permeability and integrity. (69-71) Some unsaturated free fatty acids (like oleic acid) may act as facilitators for skin permeability, thus favoring contact dermatitis. (72-74) Triacylglycerols (triglycerides) do not cross the skin but lipases from the resident cutaneous flora can break triacylglycerols into glycerol (important skin humidifier (75)) and free fatty acids. (76) Vegetable oils have a variable composition in essential fatty acids, some of them having negative effects on the cutaneous barrier due to increased concentration of oleic acid (as olive, soy, and mustard oils). (5) The benefits of the vegetable oils may be due to fatty acids effects on the lipid structures of the cutaneous barrier. (25,41) A theory suggests that fatty acids from the oils are absorbed in the blood and thus modulate the barrier function and other aspects of the immune function from other entrance gates of the pathogen agents (gastrointestinal and pulmonary mucosa), a theory based on the fact that the deficit of essential acids is associated with increased risk of translocation of intestinal bacteria (77) and that various diets with essential fatty acids can modulate inflammation, improve intestinal barrier functioning, decrease the rate of infections originating in the gut, improve pulmonary function, and mortality rates. (28,78) Oils containing medium chain triacylglycerols have the potential to improve the nutrition of the preterm infants, as these oils can be absorbed through the skin. (35,36) The recent meta-analysis performed by Clemison and McGuire (66) on 11 studies, comprising 1184 infants, mostly premature infants, evaluated the use of vegetable oils and found no significant difference as regards the incidence of invasive infections and mortality rate but significantly increased weight gain, liner growth, and better growth of the cranial circumference, concluding that topical vegetable oils are improving growth and cautioning that the analyzed studies weren't blinded.

Sunflower oil is cheap and universally available and therefore the most studied oil for infant massage in the latest years. Sunflower oils contain only 16-19% oleic acid and 68-72% linolenic acid (79), reflecting the cutaneous lipids, and very similar with the human sebum of the skin, and demonstrates regenerative, reparative, and humidifying effects, improving the cutaneous barrier when applied on the neonatal skin. (80) Sunflower oil has also the capacity to restore the intracellular lipids. (81) Oils containing triacylglycerols, as sunflower oil, may interact directly with proteins in the skin, decreasing the risk of irritation due to surfactants. (82) Glycerol trioleate in the sunflower oil binds to proteins from the stratum corneous increasing their flexibility more than mineral oils. (83) Comparative studies demonstrated that sunflower oil is superior to olive, mustard, and soy oil as regards rapidity of healing the cutaneous barrier, toxicity, and contact dermatitis risk. (4,63,84) A randomized controlled study compared sunflower oil massage to simple massage and no intervention in 69 preterm infants less than 1500 g birth weight and less than 37 weeks gestation in the first 10 days of life and found a better weight gain and no influence on the neurodevelopmental scores at 10 days of life. (43) Another randomized controlled trial on 22 premature infants, with birth weights of 1500-2500 g, compared oil massage versus standard care in the first 10 days of life and found decreased skin pH, decreased regional water losses, no significant effect on the sebum production, concluding that sunflower oil may insignificantly support the maturation of the skin barrier in preterm infants but the results may have been influenced by the lower gestational age of the infants assigned to sunflower oil massage group. (85) A comparative study of sunflower oil massage versus petroleum found similar results in decreasing the nosocomial infection and mortality rate. (52) The antibacterial effects of the sunflower oil are supported by some trials (most of them coming from developing countries) (28,52,60) and denied by other studies, most of them developed in industrialized countries. (66,67) A comparative study of sunflower oil massage versus coconut oil versus only massage in preterm infants showed that sunflower oil was more efficient in improving oxygenation and reducing the stress levels. (50) In term infants, oil massage with sunflower or olive oil showed that oils improved skin hydration but the structure of the cutaneous lipid lamellae was insignificantly influenced, implicating that oils may affect the cutaneous barrier functioning. (74)

Olive, mustard, and soy oil are oils with increased content of oleic acid and, in the light of the results of the recent studies, have the potential to disrupt the cutaneous barrier, predisposing to skin lesions. (5,71,86) Olive oil, although one of the most recommended for the skin care of the newborn even in neonatal units and maternity hospitals (87), contains 55-85% oleic acid and should be avoided in preterm and term newborns. (82,88-90) Increased risk for atopic dermatitis and exacerbation of atopic dermatitis were reported with olive oil use. (2) Mustard oil was used mostly in India but its use is now restricted due to demonstrated negative effects - increased cutaneous water loss, delayed functional maturation of the skin barrier, ultrastructural changes of the keratinocytes -, and increased risk for irritative reactions. (55) Allylisothiocyanate, the main antigen contained in mustard oil, has the potential to induce contact dermatitis. (91,92) Hypersensitivity to mustard oil was also reported. (93) Limited clinical data are available for the use of other vegetable oils for massage in the neonatal period. Coconut oil is not hydrogenated, contains 92% saturated fats and no cholesterol, and is, in fact, a mixture of short and medium chain fatty acids, especially lauric acid (44%) and miristic acid (16.8%). (35,55) Some authors are suggesting that coconut oil can be used in preterm infants as an alternative to sunflower oil but evidence is less supportive as for sunflower oil. (55,82) Safflower oil is rich in essential fatty acids and massage with safflower oil increases the triacylglycerols and essential fatty acids (linolenic and arachidonic acid) levels while massage with coconut oil increases the level of saturated fats mostly in term neonates. (35,86) Sesame oil massage, versus herbal oil, mustard oil, and mineral oil, was more efficient in improving growth parameters and sleep in newborns. (48) Other oils that have been recommended based on their increase content of linolenic acid content are grape seeds oil (55,86) and almond oil. (65)

Experts are advising also on some practical points of using vegetable oils for massage in preterm and term infants during neonatal period. Vegetable oils have also disadvantages: some of them are unstable, degradable by hydrolysis and oxidation, increasing the risk for microbial growth especially in humid and warm environments. (5) Careful attention is warranted with storage of this oils. Also, for neonates, formulations without preservatives may haste degradation (5) while many preservatives are harmful to neonatal skin. (93) Refined oils are free of impurities, have a smooth texture and almost no smell, and longer validity. (94) Refinement destroys proteins binding allergens, therefore refined oils have a decreased risk for allergic reactions (95), experts recommending individual vials of about 50 ml of extremely refined vegetable oil as safe and not toxic for preterm infants. (82,96) Cold pressed oils are not sterile and may contain bacteria and/or fungal spores, increasing the risk for infections. (82) Since oil massage is traditional worldwide, cookery and kitchen vegetable oils are sometimes used but experts are cautioning that these oils are chemically heterogeneous, sensitive to oxidation and light, and have variable biological activity and thus may have unpredictable effects when topically applied. (88,89)

F. Vegetable oil content - less known aspects

Vegetable oils are refined lipids containing mainly triacylglycerol. (97) Most of the oils are vegetal and, beyond triacylglycerol, they contain other lipid fractions. These lipids may be simple (not saponifiable) - free fatty acids, steroids, carotenoids, monoterpenes, tocopherols - or acyl lipids (saponifiable) - mono-, di-, triacylglycerols, phospholipids, glycolipids, waxes, sterol esters. (97). Other lipids and even nonlipid components are collected together with glycerides from vegetal tissues during the extraction process. These minor fractions are important for the sensorial, chemical, physical, and biological properties of the oil. Some of these fractions are responsible for oils chemical instability and for the specific taste and aroma, and are removed through refinement.

Crude oils are processed to eliminate unwanted components as phospholipids, glycolipids, free fatty acids, waxes, pigments, autooxidation products, phenolic compounds, trace metal ions, and other contaminants. The refining process consists in several steps: lecithin removal through washing with water, degumming (carbohydrates and protein removal) by phosphoric acid addition, free fatty acid removal mainly through alkali addition or distillation (for oils with high content of free fatty acids), bleaching Al-silicates and activated charcoal, and deodorization through vacuum steam distillation. (97,98)

The most important fraction of oil are triacylglycerols, esters of glycerol with fatty acids. Fatty acids are aliphatic carboxylic acids that can be differentiated through their chain length and number, position, and configuration of double bounds. Fatty acids present in oils are responsible for their physical properties (as, for example, viscosity and solid or liquid phase at room temperature), and chemical and biological properties. According to sources, each oil has a different composition in fatty acids. Table no. 1 is presenting the fatty acids composition of the most used vegetable oils. As expected, olive oil has the highest content in oleic acid, around 75%. Other oils have also a high content in oleic acid: rapeseed (canolla) and peanut oil have an oleic acid content higher than 50% while the lowest level of oleic acid is found in sunflower oil.

Table no. 2 is presenting the reported content in oleic and linoleic acid in some other edible vegetable oils. Regular mustard seeds oil (rapeseed, *Brassicacea*) has a high content in erucic acid which is harmful for humans (97,99,100) in proportions higher than 5%. (97) Varieties of rapeseeds with no erucic acid are normally used for producing the edible oils. (101) These oils are containing 68% monounsaturated fatty acids (mainly oleic acid). Other edible vegetable oils with lower oleic acid content are safflower and corn oil. Another oil with low content of oleic acid is extracted from melon seeds (lower than 18.2%). (102) The highest content in oleic acid is observed in Camelia oil (tea) (79.5%). (103) High levels of oleic acid are also seen in hazelnut, avocado, almond, and apricot kernel oils (78, 70.55, 69.9, and respectively 60% oleic acid).

A special attention must be paid to oils obtained from plant varieties genetically modified. Oils with higher oleic acid and lower linoleic acid content are preferred as they are more stable. (97,104,105) The content of oleic acid in oils from genetically modified sunflower reaches 87.4–91.2% while the regular sunflower oleic acid content is 15.0–50.9%. (106) Worldwide, areas cultivated with high oleic acid varieties increased at about 11% of total area cultivated with sunflower. (107) Other plants were genetically modified to increase the oleic acid content of the oil: an oil with 81.8% oleic acid was produced from safflower, another one with 65% oleic acid from corn, while from peanut and soya oils with 80, respectively 85.6% oleic acid were obtained. (100)

Refined oils are indicated for human use, edible or for external use. Crude oils are more flavored and contain many valuable components as carotenoids, sterols, tocopherols, phospholipids but they also contain many harmful components as free fatty acids which are more exposed to oxidation, oxidation compounds, microorganisms, proteins with allergenic potential. Regular rapeseeds are containing glucosinolates which are decomposed in esters of isothiocyanic and other volatile compounds that are hazardous to health and detrimental to oil flavor. (97) Crude oils are refined in order to increase oil stability and shelf life. Natural and synthetic antioxidants are also added. Natural antioxidants added are carotenoids and tocopherols, while butylhydroxytoluene (BHT) and butylhydroxyanisole (BHA) are used synthetic antioxidants. (97)

Conclusions

Available data regarding vegetable oil usage for massaging preterm and term infant, even though abundant, are recently challenged by studies showing that benefits and risks associated with vegetable oil use in the neonatal period are highly dependent on the fatty acid content of the oil. No clear recommendations exists about the use of topical oils for the skin care in neonates, past and recent controversies and the lack of data on long-term complicating the development of such recommendations. Parents are prone to errors in the absence of competent advise, falling often in the trap of the misconception that "what is natural is safe". (87) More studies are needed to establish the biological value of the vegetable oils in neonates, and to more clearly delineate which vegetable oil is the best in terms of efficiency and safety for massaging the preterm and term infants.

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