Echography of breastfeeding. Latest findings on anatomy of lactation and painful latch

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Introduction

In recent years the resolution of ultrasound imaging has improved dramatically rendering small anatomical structures visible. Until recently this diagnostic modality has not been applied extensively to either the lactating woman or the breastfed infant. Ultrasound research studies are now able to describe the anatomy and function (milk ejection) of the lactating breast as well as detailing the movement of the infants tongue during breastfeeding. Furthermore ultrasound has been used to examine infants with ankyloglossia before and after frenulotomy.

Breast anatomy

Descriptions of the gross anatomy of the human mammary gland are based on Astley Cooper's dissections of the breasts of women that died during lactation[1]. The breast is comprised predominantly of glandular and adipose tissue that is supported by a framework of Cooper's ligaments. The glandular tissue is comprised of alveoli lined with lactocytes that synthesis milk. The alveoli are grouped into lobules and lobes that are drained of milk by a ductal system. The ducts drain the lobules and converge into larger ducts and finally a main milk duct that then narrows and enters the nipple. Conventional texts describe 15 to 25 expanded 'sac-like' structures called lactiferous sinuses (main milk ducts) beneath the areola. Recently studies of the lactating breast using high-resolution ultrasound[2] showed fewer main ducts (mean 9; range 4-18) which is in agreement with observations during pumping [3] (mean 5; range 1-17) and the dissection of one lactating breast (4 patent ducts) [4]. Interestingly Cooper found 7-12 patent ducts in a cadavers of women that had died during lactation despite cannulating up to 22 ducts[1]. Insteadmof the typical sac like 'lactiferous sinus', ducts draining glandular tissue immediately below the nipple often merged into the main collecting duct (average 2mm in diameter) very close to the nipple (Figure 1) [2].

It is often assumed that the lactating breast is comprised predominately of glandular tissue. Ultrasound observations made during pregnancy show an increase in glandular tissue however as many as 20% of women at 6-12 weeks gestation have more adipose tissue than glandular in their breasts [5]. No simple method is available to allow the calculation of the volume of a particular breast tissue however semi-quantitative measurements made with ultrasound showed caucasian lactating mothers to have a 2:1 ratio of glandular to adipose tissue. However, the proportion of glandular tissue varies widely between women with some women having up to half of the breast comprised of adipose tissue and in others up to eighty percent of the breast was composed of glandular tissue[2].

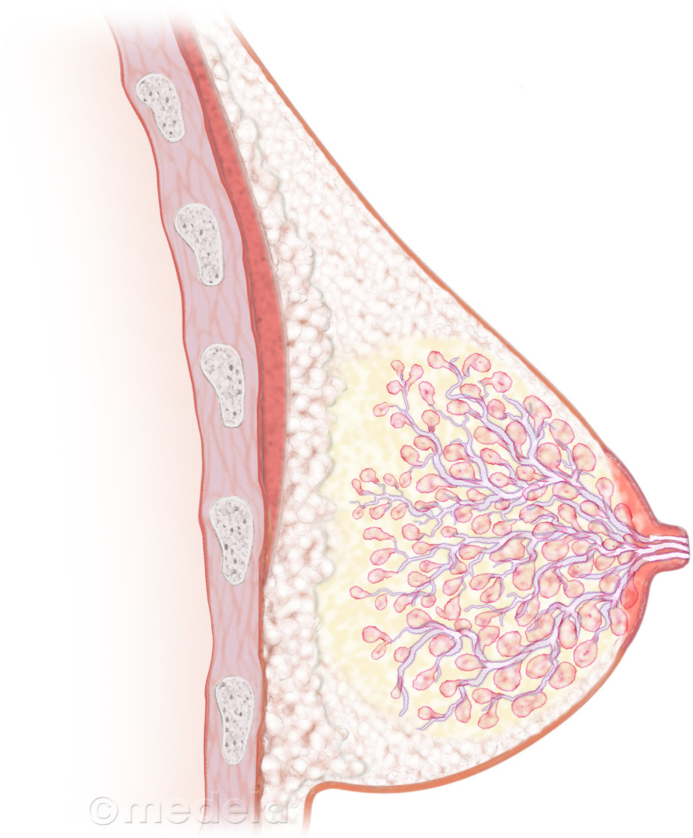

Figure 1 Anatomy of the lactating breast illustrating relatively small main milk ducts that branch rapidly under the areola (permission copyright Medela)

Milk Ejection

Most of the milk is stored in the alveolar portion of the breast with only a small proportion located in the ductal system. The milk is stored in the alveoli until demanded by the suckling infant or expressed by the mother. Stimulation of the nipple causes the release of the hormone oxytocin from the posterior pituitary gland into the bloodstream. This process is termed the milk ejection reflex. Oxytocin binds to receptors on the myoepithelial cells surrounding the alveoli. These cells then contract forcing milk from the alveoli into the milk ducts causing an increase in both intra-ductal pressure and duct diameter. At this point the milk is made available for removal by either the infant or the breast pump [6]. Milk ejection occurs within approximately 60 seconds from the start of a breastfeed and takes slightly longer with breast expression (90 seconds). However, conditioning of the reflex commonly occurs particularly in response to interaction with the infant. Spontaneous milk ejections may also occur between breastfeeds. Oxytocin has a relatively short half life (45 seconds to 3 and a half minutes) therefore, milk is only available from the breast for a short period time. Multiple releases of oxytocin commonly occur throughout a breastfeed or expression [7] however the mother may not be necessarily aware of these. Increased milk intake by the infant has been associated with increased numbers of milk ejections. Milk ejection is critical to the continued synthesis of breastmilk as ineffective emptying of the breast results in accumulation of a feedback inhibitor that reduces the production of milk [8]. Although many mothers are able to sense milk ejection (pins and needles, tingling, pressure, pain, nausea, thirst) a significant proportion do not [9].

Ultrasound has the unique ability of visualising changes of structures in real-time. This makes ultrasound an ideal non-invasive technique to detect milk ejection in the lactating breast during both breastfeeding and breast expression.

Studies using ultrasound imaging to monitor milk ejection during both breastfeeding and pumping show an increase in milk duct diameter often accompanied by milk flow visualised as small white flecks moving towards the nipple. The degree of milk duct dilation is highly variable between women with some showing large increases and others very small increases. As the effect of oxytocin diminishes back flow of milk into the breast is often seen along with a decrease in duct diameter. Studies have shown wide ranges in the number of milk ejections (1 to 12 milk ejections) between women during both breastfeeding and expression [10 11].

Breastfeeding

Much of the research regarding the mechanism of milk removal by the infant is based on bottle feeding [12-14] thus there is limited investigation into the sucking mechanisms of the infant during breastfeeding. Much of the controversy that exists regarding sucking theory is focused on whether vacuum is the primary mechanism of milk removal is vacuum (negative pressure) or compression of the nipple/breast (positive pressure).

Simultaneous measurement of the vacuum applied by the infant and ultrasound imaging of tongue movement during breastfeeding has further clarified milk removal from the breast. Geddes et al, found that milk was removed during the application of negative pressure (first half of the suck cycle) as the tongue lowered and that the milk bolus was cleared to the pharynx during the decrease in negative pressure (second half of the suck cycle) as the tongue was raised[15]. This adds to the mounting evidence in the literature that the development of adequate vacuum is critical to the effectiveness and efficiency of milk removal by the infant.

Nipple pain

Despite nipple pain being a major reason for early weaning of the infant, little investigation has been carried out into the causes and treatment of this condition. For the most part researchers and clinicians have focused on the positioning and attachment of the infant to the breast and nipple infection as the main causes of nipple pain. Unfortunately a proportion of women and infants do not respond to treatments and advice for these problems indicating a strong need for more research in this area.

Mavis Gunther suspected that one some infants might be exerting high intra-oral vacuums during breastfeeding thus causing pain to the mother. Gunther however was only able to measure intra-oral pressure of a 2-day-old infant during breastfeeding and found that the infant applied pressures up to -200 mmHg which she speculated caused capillary damage to the nipple and thus caused the mother pain [16].

More recently we have shown that infants of breastfeeding mothers who report nipple pain exert stronger baseline and peak vacuums compared to infants of mothers not experiencing pain [17]. These results support Gunther's observations that high vacuums should be considered as a cause of nipple pain. In addition ultrasound scans suggest that these infants may also compress the nipple during feeding and we are currently analysing these.

Ankyloglossia

Ankyloglossia (tongue tie) refers to a sublingual frenulum that is short, is inelastic and/or is attached too distal from the tongue tip or too close to/on the gingival ridge. This restricts the movement of the infants tongue [18] and therefore may have detrimental effects on both feeding and speech. Although not every infant with ankyglossia will have feeding difficulties, some infants exhibit poor weight gain , speech and feeding problems in later life, and poor oral hygiene [19]. Nipple pain during the early stages of lactation is a common symptom of mothers whose infant has ankyloglossia [20]. In the event of failure of conventional treatment to resolve feeding difficulties the lingual frenulum may be surgically released (frenulotomy). This is a simple procedure that does not require anaesthesia for infants under the age of four months [18].

In an attempt to assess the effect of frenulotomy we used ultrasound investigate the tongue movement of breastfeeding infant with ankyloglossia both pre- and post-frenulotomy [21]. Measurement included ultrasound scans pre and post frenulotomy (within 7 days), milk intake, pain scores and LATCH scores. Post-frenulotomy milk intake over 24 hours, milk transfer rates, LATCH and pain scores improved. Ultrasound pre-frenulotomy identified two types of nipple distortion. Infants, who placed the nipple close to the hard-soft palate junction and compressed the base of the nipple and others that placed the nipple further from the hard-soft palate junction subsequently compressing the tip of the nipple. Scans post frenulotomy showed a resolution of nipple distortion during breastfeeding for all but for one infant. Further investigation of both intra-oral vacuum and tongue movement of breastfeeding infants with ankyloglossia is required to further our understanding of this condition.

Conclusion

Considering the large contribution of ultrasound imaging have made to the understanding of the physiology of lactation this modality has the potential to become a useful diagnostic tool for the mother-infant dyad experiencing breastfeeding difficulties.

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