on outdated material it is not likely that any borough has moved from one extreme to the other in social grading. The trend of the incidence of measles in both these groups of boroughs was very similar, and there was no difference of any importance between them. A summary of their positions is given in Table III. It appears from these values that the relative incidence of measles was constant during the period, although Group 1 had relatively a larger outbreak than Group 2 in 1950 owing to a summer rise in incidence. The introduction of the National Health Service in 1948 did not have any differential effect on the incidence.

In recent years the measles attack rate has been twice as large among pre-school children as among school-children, and the ratio of these attack rates has been practically constant during the past nine years.

Summary

The number of notifications of scarlet fever, whooping-cough, and measles rose in the six months preceding the operation of the National Health Service in 1948 and has remained above the level prevailing in 1946-7.

Scarlet Fever.—Although the incidence in the first quarter of 1948 was unusually high the subsequent level of the notifications does not suggest that the prevalence of scarlet fever has undergone much change in recent years. There is, however, a suggestion that since 1948 the disease has tended to be more concentrated on the pre-school child.

Whooping-cough.—A large increase in the numbers of notifications has occurred since 1948. If the pre-war estimate that 70% of the child population have an attack of whooping-cough before age 15 is still valid, then only about one-half of the cases are being notified. But if immunization against whooping-cough has been carried out on large enough numbers it is possible that the higher level of notifications since 1948 is due to a real increase in prevalence.

Measles.—The level of notifications of measles has increased in recent years. The whole of the rise in 1948 cannot be explained by increased case-finding and reporting, and it seems that there was a real rise in prevalence just before the operation of the National Health Service. The proportion of children under 15 who suffer a notifiable attack of measles has risen from about one-half in the early 1940's to about two-thirds in the last five years. It seems probable that there has been a real increase in prevalence during these years.

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The Pakistan Minister for Health, Dr. A. M. Malik, in his country's parliament last month, gave details of steps taken in co-operation with the World Health Organization to improve public health and provide facilities for medical treatment. He said that the United Nations International Children's Emergency Fund had offered a 700 tons annual capacity plant for making Pakistan self-sufficient in her requirements of D.D.T. Work on the construction of the buildings and installations of the plant at Naushera in the Frontier Province had progressed considerably, and the plant should go into production in July. A B.C.G. vaccination campaign had been started in 1949, and so far more than 2,200,000 persons had been vaccinated. In East Pakistan a three-year programme for improving teaching and practice facilities at a nursing school in Dacca had been launched.

CLINICAL AND CHEMICAL STUDIES IN HUMAN LACTATION*

VI. THE FUNCTIONAL CAPACITY OF THE BREAST

BY

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There is little published evidence about the relationship of the size of the breast to its functional efficiency, but it is generally held by clinicians that no strong relationship exists. On the other hand, there is a well-recognized relationship between the size and function of the cow's udder: Gowen and Tobey (1927) computed that 1 lb. (450 g.) of udder would produce 1 lb. (450 ml.) of milk in three hours. It is reasonable to expect that, if there were any clear relationship in women, then this knowledge would have been incorporated into the general folklore of lactation; but the only idea occurring sporadically in the old literature, and still commonly held to-day, is that the very large breast is likely to have a poor performance. Nevertheless, Lussky (1951), in a hospital study, found that successful lactation occurred in 50.2%, 36.6%, and 19.0% of women with "large," "medium," and "small" breasts respectively.

The capacity of the breast to secrete milk probably depends on the amount of functional tissue it contains, and this is not necessarily related to the size of the breast: not only is there a layer of subcutaneous fat of variable thickness, but the gland itself, as has been demonstrated in post-mortem material by Engel (1941), shows an enormous variation in the ratio of parenchyma to fibrous tissue, ranging from almost 100% secretory tissue to almost none.

It would nevertheless be surprising if there were no relationship whatever between the size of the breast and its functional ability, and it is of some clinical interest to determine accurately what that relationship is.

For comparative studies, an estimate of the amount of functional tissue might be made in the living subject by measuring changes in breast size occurring in response to the menstrual cycle or to pregnancy. Engel (1947) believes that subjective impressions of breast enlargement during the premenstruum are a good index of the breast's functional equipment, presumably on the basis that the enlargement is due to proliferation of glandular tissue. This may be so, but breast changes during the cycle are due only partly to such proliferation, and, in any case, mostly to non-secretory tissue; much of the enlargement may be caused by oedema in the stroma (Geschickter, 1945), perhaps as part of a more general mechanism of water retention, and not directly related to the amount of gland present. The enlargement which occurs in pregnancy is likely to be a more reliable index of the amount of functional tissue, since it is due mostly to the proliferation of the gland. No study of these changes has been reported.

Previous Technique of Breast Measurement

Ingleby (1949) measured wax impressions taken from serial plaster casts of the breasts of 17 women during the menstrual cycle, and appeared able to measure differences of the order of 30 ml. Geschickter (1945) estimated the menstrual enlargements of the breasts in two women by measuring the

*Parts I, II, and III were published in the *Journal* on January 23, p. 175; and Parts IV and V on January 30, p. 249.

differences in the amount of water required to fill a glass vessel, applied to the chest and enclosing the breast. He describes a difference in one subject of only 15 ml., but this difference is likely to be less than the experimental error of such a method. Reimann and Seabold (1933), incidental to a study of breast lesions during the menstrual cycle, calculated areas of the x-ray shadows of breasts in profile, but this method is clearly subject to a good deal of inaccuracy and is, in any case, not comparable with three-dimensional estimations.

The fundamental difficulty in the determination of breast volume by any method *in vivo* is to define the posterior surface; that is, the chest wall underlying the breast. If a plaster cast of the breast is taken, then it is not difficult to curve the posterior wall to an arbitrary approximation of the chest contour, but, if a series from the same subject are to be made, then an artificial "chest wall" must be made first and all subsequent models fitted to it, so that the posterior surface, if not true to life, is at least constant for all the models. The method of making plaster casts takes time and requires a considerable degree of co-operation from the subject. It is also unsatisfactory for the large pendulous breast.

Several indirect methods which might be used to assess the functional tissue of the breast have been suggested. Pickles (1953) has described two rather complex techniques which will indicate the amount of blood flow through the breast, but there is no evidence of a fixed relationship between blood flow and breast function, and there are many circumstances which will confuse such estimations. An even less direct method of estimating blood flow is by infra-red photography (Bowes, 1950), but the amount of incident light is difficult to control and quantitative interpretation of the photographs would not be simple.

Method

In this investigation a method of water displacement has been used to study breast size.

The apparatus is illustrated in Fig. 1. It consists of a "perspex" container,* shaped to fit closely to the average

FIG. 1.—The method of estimating breast size. 1, Tube for filling apparatus. 2, Tube for emptying apparatus. 3, Tube for inflating the sealing ring.

chest wall round the breast, the seal being ensured by an inflatable rubber ring at the periphery. This ring is inflated by mouth and forms a cushion with a section of about $\frac{1}{4}$ in. (6 mm.) diameter. This arrangement proved to be leak-proof in all but two cases examined, the exceptions being small women with thin narrow chests.

With the subject seated upright, the apparatus is held firmly against the chest and filled with water at body tem-

perature through an opening at the highest point, air escaping from a small hole alongside. When it is completely filled the water is drained off through another tube into a measuring cylinder. This volume of water is subtracted from the volume of the container, which has been previously determined using a perspex sheet curved to represent an approximately average chest wall. All measurements were made by one observer to ensure, so far as possible, that the rubber ring was inflated to a similar pressure for each observation, and that the apparatus was held against the chest wall with similar force. Results were reproducible to within 20–30 ml., an error of about 5%. Only the left breast was measured in all subjects except one, in whom the breasts were obviously asymmetrical, and in this woman both breasts were measured and the mean was taken.

Measurements were made on the seventh post-partum day, immediately following complete emptying by the "humalactor," in 86 primiparae and 23 multiparae. In nine of the primiparae and two of the multiparae measurements were also made during the course of pregnancy, beginning at the third month.

A detailed history of breast reactions during the menstrual cycle was obtained from 50 of the subjects whose breasts were measured.

The method of collection of milk samples has been previously described (Hyttén, 1954a); the volume and composition of the seventh-day milk for all these subjects is included in Table II of an earlier paper of this series (Hyttén, 1954c).

Results

For the 86 primiparae, the mean size of the empty breast on the seventh day of lactation was 787.0 ± 219.6 ml., and for the 23 multiparae 756.9 ± 314.0 . The difference is not statistically significant.

Fig. 2 shows the relationship between breast size and the milk output on the seventh day of lactation. The calculated

FIG. 2.—The relationship of milk yield on the seventh post-partum day to the size of the left breast. The regression lines calculated from these data are superimposed, the continuous line representing primiparae, the broken line multiparae.

regression lines for the primiparae and multiparae are superimposed. There was a correlation in the primiparous series ($r = +0.31$) significant at the 1% level, and a correlation of about the same magnitude for the multiparae ($r = +0.35$), although this was not statistically significant, probably because of the small numbers. The precision with which the seventh-day milk output could be predicted from breast size was not significantly different in the two groups, although this again may be due to the small sample.*

There was no correlation between the size of the breast and the fat, protein, or lactose content of the seventh-day milk.

*The regression equation combining both sets of data is:
Seventh-day milk output = 0.23 (breast size in ml.) + 260 ml.
 ± 0.07 .

*The apparatus may be obtained from Arnoplast Ltd., South Hillingdon Farm, Kelhead Avenue, Glasgow, S.W.2.

In an attempt to reduce the effect of "fatness" on the size of the breast, an index was calculated by dividing the measured breast size by the weight-to-height ratio of the subject. In this way a breast of the same actual size would have a higher index in a thin woman than in a fat woman. The correlation between this index and the seventh-day milk output was no better than the correlation of the measured breast size and the seventh-day milk output.

Of the 50 women questioned about breast symptoms in the premenstrual period, only 10 (20%) had noticed any reaction at all. The mean seventh-day milk output of these 10 women was 573 ml., and for the remaining 40, 430 ml., the difference being statistically significant ($P < 0.01$). The difference between the mean breast sizes of these two groups (838 ml. and 746 ml.) was also statistically significant ($P < 0.01$).

The serial breast measurements taken throughout pregnancy on 11 subjects do not permit an accurate interpretation of the pattern of breast enlargement, since in this pilot experiment measurements were made during routine antenatal visits and were too widely spaced. Moreover, the estimation of small increases with an apparatus liable to an error of 20-30 ml. is not close enough. Nevertheless, in five cases there was almost no further increase after about the twenty-fourth week of pregnancy, the remainder continuing to enlarge, but at a slower rate than during the first half of pregnancy.

The Table shows the breast sizes at the third month of pregnancy, together with the post-partum breast sizes, milk output on the seventh post-partum day, and the ages of the 11 subjects.

Serial Breast Measurements in 11 Subjects

Case No.	Age	Left Breast Volume (ml.)			Seventh-day Milk Volume (ml.)
		3rd Month	Post-partum	Enlargement	
113	19	295	775	480	800
129	25	295	490	195	455
183	28	860	960	100	390
184	24	620	740	120	565
210	22	700	1,030	330	480
237	20	510	720	210	385
239*	31	410	760	350	895
246	25	990	1,050	60	250
248	21	785	1,050	265	565
263†	41	1,800	1,920	120	600
265	22	600	580	- 20	180

* Second pregnancy. † Fifth pregnancy.

Results from the nine primiparae only were subjected to statistical analysis. There was a high correlation between the pregnancy enlargement of the breast and its milk output on the seventh post-partum day ($r = +0.87$), significant at 1%, and this can be clearly seen in the scatter diagram (Fig. 3). The regression line for primiparae has been drawn, and data for the two multiparae are also shown. There was no relationship between the initial size of the breast and its subsequent enlargement.

FIG. 3.—The relationship of milk yield on the seventh post-partum day to the enlargement of the breast which occurred during pregnancy.

There are clearly not enough results to test statistically the effect of age, but it can be seen from the Table that, apart from subject No. 265, who showed no enlargement at all, the four subjects aged 22 or under all had an enlargement of more than 200 ml., and the four older than this all enlarged by less than 200 ml. This confirms the clinical impression that while the very young primiparae are usually first seen at the antenatal clinic with tender swollen breasts and uncomfortably tight clothes, the older primiparae tend to show little reaction at the same stage of pregnancy.

Multiparae present an entirely different picture, since the glandular enlargement occurs into the loose stroma which has been left by involution from the previous lactation. There is therefore no tension, and the enlargement which occurs is not readily appreciated by either patient or examiner.

Discussion

Although there is an undoubted correlation between the size of the lactating breast and its milk production in hospital, the scatter is wide and the predictive value for an individual breast is obviously low. Fig. 2 does suggest, however, that the smallest breasts have a ceiling of performance on the seventh day.

In view of the differences in the actual shape of the chest wall which must occur between subjects, the results of measurement of breast size are not strictly comparable, but the error involved is probably slight in relation to the large range of values for breast size. Again, the milk output on any given day is not necessarily equivalent to the breast's potential yield, since it may have a considerable reserve which it does not exhibit in the absence of an appropriate demand. An artificial demand, such as the stripping of breasts by manual expression, may or may not provide this, although Waller (1950) claimed that the breast could be brought to maximum productivity during the first week of lactation by this means. However, Sydow (1952) has shown a close correlation between the milk output on the sixth day and the subsequent success of lactation, so that milk output in hospital can be accepted as of at least some value in indicating the true capacity of the breast.

It is difficult to interpret the striking relationship between breast size and breast-feeding in Lussky's series, since only half of the best group, those with "large" breasts, left hospital breast-feeding, in contrast to the overall hospital breast-feeding rate in this country of between 80 and 90% (Ministry of Health, 1951). It is unlikely that breast size was the only or even the major factor involved.

Two aspects of breast size must be kept in mind: one is the ability to produce milk, and the other the ability to store it. The small breast will suffer a double disability, and below a certain size this lack of storage capacity may become critical. Such an effect has been demonstrated in a previous paper (Hyttén, 1954b). Subject No. 74, with a breast size of only 530 ml., produced about 120 ml. of milk at each feeding; that is, the amount of milk in the breast at, say, 2 p.m., after four hours' secretion, was 120 ml., and at 6 a.m., after eight hours' secretion, the amount was no more, clearly indicating an upper limit to storage capacity.

The range of breast capacity may, in part, explain the gradual falling off in breast-feeding which occurs during the course of the first two months, since lactation will become unsatisfactory when an infant has outgrown the supply which the breast can secrete or store.

The degree of breast enlargement occurring during pregnancy, which is probably due to changes in the functional tissues alone, would be expected to show a high correlation with lactation performance, although it must be stressed again that the results from so few subjects can only be tentative. Data for increase in size are of comparative value only, and in no sense absolute measurements of the gland itself; much of the increase must be due to other changes, such as increased vascularity, but these are likely to parallel closely the growth of the glandular tissue.

The measurement of the enlargement of the breast during the whole course of pregnancy is in practice extremely difficult, since women are not usually seen until the third month, by which time some enlargement of the breast has already occurred; in fact, it is usually claimed that the most rapid enlargement occurs during the first three or four months. The amount of enlargement which is missed, however, should be proportional to the total breast enlargement, provided that the measurements are made at approximately the same stage of pregnancy, so that for a comparative study it is probably no serious disadvantage to have missed the first two months. A large-scale investigation of measurements during the entire pregnancy will be required to establish the precise pattern of enlargement. The suggestion that the most rapid enlargement occurs at the beginning of pregnancy is probably fallacious, since it is based on subjective impressions of discomfort which are greatest at this stage, probably because of vascular engorgement. The unreliability of such subjective impressions as an index of enlargement is supported by the finding that there is seldom any difference in size between the breast on the seventh post-partum day and the same breast at the end of pregnancy, although it is also claimed that the first few days of the puerperium are a period of rapid enlargement.

For the same reason a history of change of size of clothes required during the pregnancy can be misleading. Subject No. 113, for example, whose left breast increased in volume by 480 ml. (160%) said she noticed almost no change in the size of the breasts and had worn the same brassière throughout pregnancy.

It has been suggested that a simpler investigation could be undertaken by serial circumferential chest measurements, but these are unlikely to provide anything but the crudest information, because the breast may change in shape without becoming any more protuberant. In fact, Engel's (1941) finding that breasts with little glandular tissue have it disposed round the periphery suggests that a "spreading out" rather than a forward enlargement may be commonly found.

The few cases so far investigated suggest that breast enlargement during pregnancy in primigravidae is greatly influenced by age, and additional evidence, to be given in a later paper, shows that failure to establish lactation owing to an inadequate milk supply increases rapidly with age in primiparae. It is possible that the long delay, sometimes of over twenty years, from the time of puberty may lead to disuse atrophy, or it may be that small breasts are among a number of physical characteristics which make early marriage and child-bearing less likely.

Although the reason for breast symptoms during the menstrual cycle is not altogether clear, their occurrence seems to be a rough indication that the breast is well equipped, although the converse is by no means necessarily true. The small proportion of women who report the phenomenon (20%) is perhaps surprising, but it agrees well with Engel's (1947) findings that only in 20-30% of breasts is the structure predominantly glandular.

The different reaction to pregnancy shown by multiparae may be due to their having already laid down much of their glandular tissue during a previous pregnancy. The primipara reacts by encroaching on and replacing the fatty stroma of the breast with growing gland, but when the lactation is over only a small part of this stroma is reformed (Geschickter, 1945), and the characteristic flabby breast, which again becomes firm only during another lactation, results. Although only two multiparae had their breasts measured during pregnancy in this series, it can be seen from Fig. 3 that they have a higher milk production for the same degree of enlargement in pregnancy than primigravidae. Similarly, although the difference between the correlations of breast size with milk output in primiparae and multiparae is not statistically significant, nevertheless the regression lines (Fig. 2) confirm this parity difference, the multiparae having a better milk yield for the same size of breast. This is in accord with the histological findings of

Langer (1851), who found an increased amount of active breast tissue in women who had had repeated pregnancies.

Much of the variation in breast size and quantity of glandular tissue between individual women can probably be explained on the same basis as the difference in milk composition (Hyttén, 1954d)—that is, the absence of selective breeding for lactational ability in human society. In other mammals the lactating gland is "characterized by the absolute predominance of glandular tissue" (Engel, 1947), but this is true of only 20-30% of human lactating breasts.

No relationship has been found between the size of a breast and the composition of the milk it secretes. It is probable, then, that women who are unable to provide milk of adequate composition are not necessarily the same persons who are unable to provide sufficient milk because of inadequate mammary glands. There are therefore two groups whose lactation will be unsatisfactory, and it is not surprising that so many mothers resort to artificial feeding because of a dissatisfied baby.

Summary

The size of the lactating breast was measured, after emptying in 86 primiparae and 23 multiparae, by a method of water displacement.

There was a significant correlation between breast size and the output of milk on the seventh day of lactation, but not with any of the major constituents of milk.

In nine of the primiparae and two of the multiparae the amount of breast enlargement during pregnancy was also measured; the first measurement was made during the third month of pregnancy. Wide variations in the amount of enlargement occurred, and this was closely related to milk output.

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Because full particulars are not always given on prescriptions, the dispensing and pricing of prescriptions ordering certain Schedule IV poisons are proving unnecessarily difficult. This is stated in a recent notice from executive councils to practitioners (ECN/140). The difficulty particularly arises with drugs which are put up in several strengths, as unless the strength is stated prompt dispensing becomes impossible. Common examples of such drugs are "amytal" tablets (amylobarbitone), "amytal sodium" capsules (amylobarbitone sodium), "anthisan" tablets (mepyramine maleate), "benadryl" capsules (diphenylhydramine hydrochloride), "butazolidin" tablets (phenylbutazone), "nembital" capsules (pentobarbitone sodium), "phenergan" tablets (promethazine hydrochloride), phenobarbitone tablets, "seconal sodium" capsules (quinabarbitone sodium), quinalbarbitone tablets, and various sulphonamide preparations. In addition to the name, quantity, and dose of these drugs, the strength must also be given.