TWO NEW STATISTICAL PROCEDURES TO JUDGE CIRCULATORY FUNCTIONS AND THEIR APPLICATION TO GYNECOLOGICAL PATIENTS, ESPECIALLY TO UTERINE CANCER CASES

YURO SASAKI

Department of Obstetrics and Gynecology, Yamaguchi Medical School, Ube

(Received for publication, November 8, 1952)

With the recent advance in operative technique and anesthesia, and because of the use of antibiotics and the more careful attention given to circulatory functions, the mortality of the surgical patients has markedly decreased. The danger of circulatory failure, however, during and/or after operation still persists, and remains to be one of the causes of the not infrequent deaths in gynecological surgery, especially of uterine cancer cases. Therefore, it is of the utmost importance to examine the circulatory functions and to prognosticate their post-operative conditions pre-operatively.

With regard to the circulatory functinns we know two functions, the cardiac and the peripheral. The wellknown "Shock" which may often connect with surgery, is the reflex of disturbed peripheral. circulatory functions. So, we have to examine and judge two functions, the cardiac and the peripheral circulatory functions, pre-operatively.

In this paper, the author will describe two new statistical procedures to judge circulatory functions, with the results of their application to gynecological patients, especially to uterine cancer cases.

1. A NEW STATISTICAL PROCEDURE TO JUDGE THE PERIPHERAL CIRCULATORY FUNCTION, AND ITS APPICATION TO GYNECOLOGICAL PATIENTS, ESPECIALLY TO UTERINE CANCER CASES

Procedure

As a method to test peripheral circulatory functions, there has been a publication "Stehversuch" reported in 1938 by Bickenbach[1], Women Clinic of the University of Göttingen, Germany, in which the blood pressure and pulse rate are measured in lying and standing positions. The author has statistically investigated the variability of these values which differ in the different positions. As the first step, it is necessary to know the distribution of their population. Since it has been reported by some investigators that the logarithm of human

blood pressure distributes normally, the author has tested this reported principle on the patients admitted in our clinic. For this purpose, the maximum blood pressures were measured, their logarithm calculated, and then the statistical "Try and Errov Method[2]" was applied to the values measured and calculated. In this way, the above mentioned principle has been confirmed to be valid. That is to say, the logarithm of human maximum blood pressure (in mm Hg.) can be supposed to distribute normally (Normal Population).

The distribution function of normal population is defined as:

$$F(x)=\int_{-\infty}^{x}\frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{-(x-m)^2}{2\sigma^2}}dx$$

where m and σ^2 are the mean and the variance of population.

In the same way, the population of human pulse rate was observed. It was found that the pulse rate per minute is hardly supposed to distribute normally, but the cube root of its reciprocal can be supposed to do so. Then, Bickenbach's "Stehversuch" of patients was made and their maximum blood pressure and pulse rate in lying and standing positions were recorded. Statistically, each of the observed values either of blood pressure or of pulse rate consists of two variables, one in lying, the other in standing position.

In order to judge these two variables together, the auther has employed the "Rejection Ellipse[3]" of normal population consisting of two variables. The employed formula of the Rejection-Ellipse was:

$$F=\frac{(N-2)N}{2(N+1)\Delta}\left\{\Phi_{22}(X_1-\bar{x}_1)-2\Phi_{12}(X_1-\bar{x}_1)(X_2-x_2)+\Phi_{11}(X_2-\bar{x}_2)\right\}$$

where N: sample size,

F: value of F-distribution, d. f. 2, (N–2), under a certain risk rate,

$\bar{x}_1$, $\bar{x}_2$; sample means,

$\Phi_{11}=\Sigma x_1^2-N\bar{x}_1^2$,

$\Phi_{12}=\Phi_{21}=\Sigma x_1x_2-N\bar{x}_1\bar{x}_2$,

$\Phi_{22}=\Sigma x_2^2-N\bar{x}_2^2$,

$\Delta=\Phi_{11}\Phi_{22}-\Phi_{12}^2$,

Using this formula under 5% risk rate, the author calculated two Rejection-Ellipses of maximum blood pressure and of pulse rate from the data of the materials picked up randomly from the patients, who had shown no clinically noticeable symptoms of circulatory disorder ever before, during and/or after operation. In this calculation, of course, the logarithm of maximum blood pressure and the cube root of the reciprocal of pulse rate per minute in "Stehversuch" were used as normally distributing variables. Fig. 1 and 2 indicate these calculated and graphed Rejection-Ellipses.

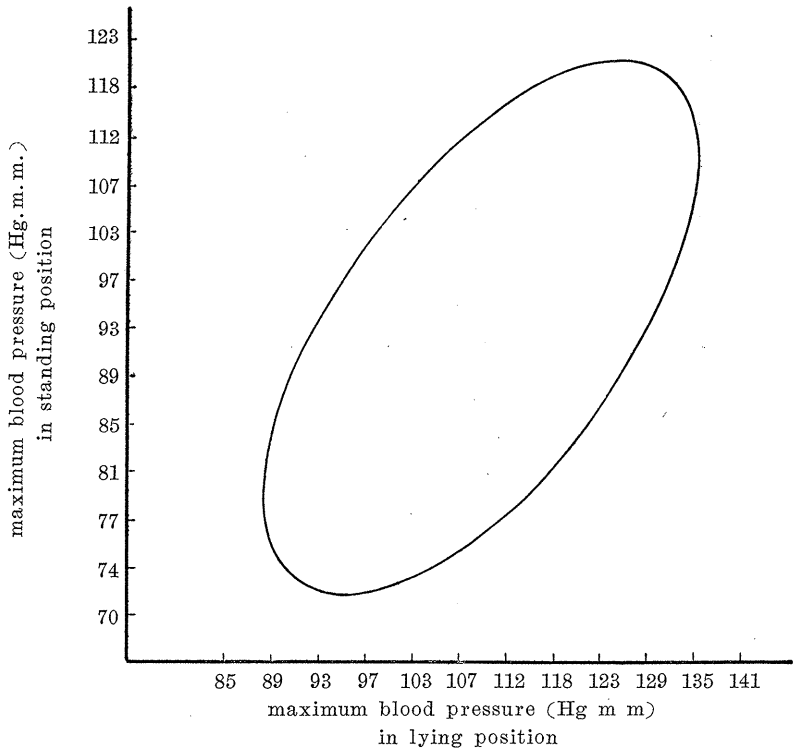

Fig 1. Rejectiion Ellipse for maximum blood pressure with 5% risk rate.

Each of the two values observed in the pre-operative "Stehsuch" of the patients, whose peripheral circulatory functions were supposed not to have been disturbed before, during and/or after operation should within its own Rejection Ellipse under 5% risk rate. Accordingly, these two Rejection-Ellipses may be regarded as the normal range of maximum blood pressure and pulse rate in "Stehversuch", and the following classification can be made of the results of the "Stehversuch" by using these two Rejection-Ellipses as judging standards:

Proposed Classification of the Results of "Stehversuch"

Group I		Maximum blood pressure and pulse rate are within its own Rejection-Ellipse
Group II	(a)	Maximum blood pressure is out of its Rejection-Ellipse, but pulse rate within its Rejection-Ellipse
	(b)	Maximum blood pressure is within its Rejection-Ellipse but pulse rate out of its Rejection-Ellipse
Group III		Maximum blood pressure and pulse rate are out of its own Rejection-Ellipse

According to this classification, the patients of Group I may be judged to

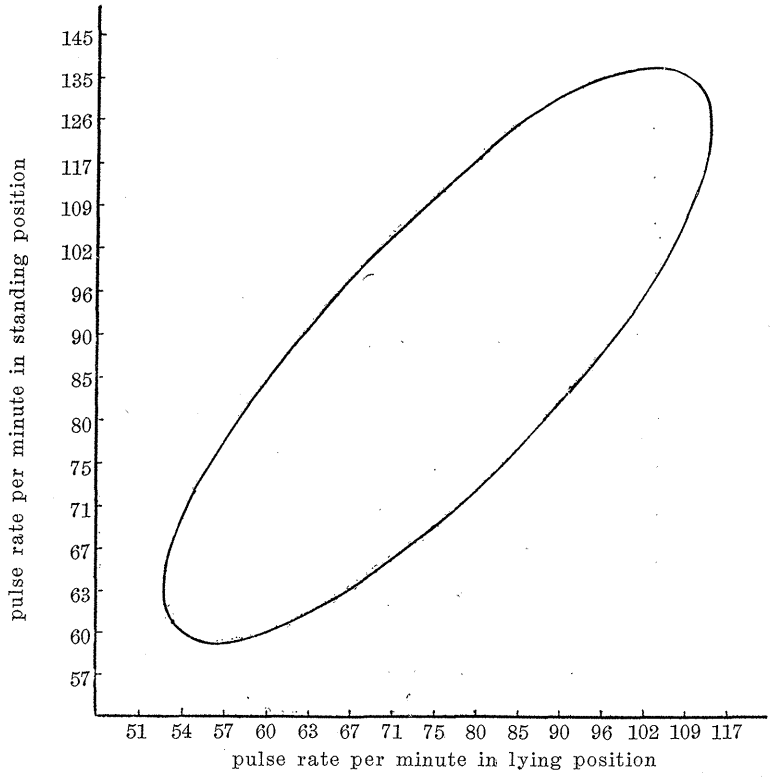

Fig. 2 Rejection Ellipse for pulse rate on 5% risk rate.

have a normal peripheral circulatory function which is probable not to be disturbed during and/or after operation, while those of Group II and III may be supposed to have an abnormal function which will probably be disturbed when the operation takes place So, the operation of Group II and III should be performed with special care.

Application

According to our method described above, our patients were classified on the basis of the pre-oporative "Stehversuch" as shown in Table I.

TABLE I

Classification	Gynecological non-cancer patients	Uterine cancer cases	Total
Group I	92 (87.6%)	20 (64.5%)	112
Group II (a)	9 (8.6%)	7 (22.6%)	16
Group II (b)	4 (3.8%)	2 (6.5%)	6
Group III	0 (0.0%)	2 (6.5%)	2
Total	105 (100.0%)	31 (100.0%)	136

In this table it can be seen that Group II and III constitute 12.4% of non-cancer patients and 35.6% of uterine cancer cases. Therefore, it is sure that there are more patients having abnormal peripheral cisculatory function in uterine cancer cases than in non-cancer cases.

The circulatory conditions of our patients during and after the gynecological operations were carefully observed to determine whether the so-called "post-operative circulatory disturbances" did occur or not. Under the so-called post-operative circulatory disturbances the auther understands not only the conditions which are so severe to be fatal but also the conditions in which blood transfusion and/or fluid infusion and other injections of cardio-angiotonica are clinically indicated to be indispensable during and/or after operation. Among the non-cancer gynecological patients only one case (0.95%) of 105 operated was with such disturbances; whereas in uterine cancer patients 11 cases (39.3%) of 28 operated had such disturbances. So, we can say that the so-called post-operative circulatory disturbances occur more frequently in uterine cancer cases than in the other gynecological operations. Table II shows the relationship between the incidence of such disturbances and the groups of patients classified according to the pre-operative "Stehversuch" in uterine cancer cases.

This table shows that the post-operative circulatory disturbances occur more frequently in Groups II and III than in Group I.

TABLE II

Classification	So-calld post-operative circulatory disturbances		Total
	not occurred	occurred	
Group I	15 (83.4%)	3 (16.6%)	18 (100%)
Group II (a)	2 (33.3%)	4 (66.7%)	6 (100%)
Group II (b)	0 (0.0%)	2 (100.%)	2 (100%)
Group III	0 (0.0%)	2 (100.%)	2 (100%)
Total	17 (60.7%)	11(39.3%)	28 (100%)

On the basis of above described facts, it may be concluded that the proposed classification is useful to prognosticate the post-operative circulatory conditions of gynecological patients, especially of uterine cancer cases.

SUMMARY

The author has proposed a new classification of the results of Bickenbach's "Steheversuch" using two statistical Rejection-Ellipses of maximum blood pressure and pulse rate. Adopting this statistical procedure in the gynecological clinic, the author has demonstrated that there are more perirheral circulatory disorders in uterine cancer patients than in non-cancer gynecological cases, and that this new classification of the results of the pre-operative "Stehversuch" is useful to prognosticate the post-operative circulatory conditions of gynecologi-

cal patients, especially of uterine cancer cases.

2. A New Statistical Procedure to Judge the Cardiac Function by Electrocardiogram (E. C. G), and its Application to Gynecological Patients, especially to Uterine Cancer Cases

Procedure

It is a well known fact that the relative elongation of the Q-T period measured on the E. C. G. is often recognized at patients suffering from myocardial disorders. Therefore, whether the Q-T period is normal or not should be determined to find such disorders. For this purpose, the author investigated the relationship between the Q-T period and the R-R period on the E. C. G. statistically. Since the R-R period is the reciprocal of pulse rate and the cube root of pulse rate distributes normally, it is beyond question that the cube root of the R-R period distributes normally. This was also comfirmed from the author's data by applying the statistical "Try and Error Method". At the same time, it is certified that the Q-T period measured in 1/100 second unit on the E. C. G. distributes normally.

The R-R and Q-T periods were measured on the pre-operative E. C. G. of our patients who had no clinical abnormalities in cardiac functions and no circulatory disturbances during and/or after operation, and, taking the Q-T period (1/100 second unit) and the cube root of R-R period as normally distributing variables, the "Rejection-Ellipse" was calaulated by using the above described formula under 5% risk rate. Figure 3 shows this graphed "Rejection-Ellipse" for the R-R and Q-T periods.

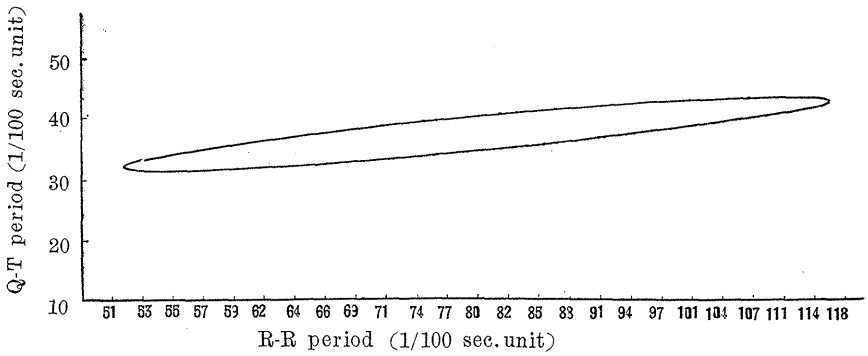

Fig. 3 .Rejection Ellipse for R-R & Q-T period with 5% riskrate

This Rejection-Ellipse is proposed to show a normal range of the R-R and Q-T periods on E. C. G. taken in restfully lying positions. Therefore, these periods which are out of the Rejection-Ellipse can be judged to signify abnormal myo-

cardial functions, i. e , myocardial disorders.

Application

The correlation between the "Rejection-Ellipse" and the gynecological diseases (uterine cancer or non-cancer) is shown in Table III.

TABLE III

R-R & Q-T periods	No. and % of non-cancer cases	No. and % of uterine cancer cases	Total
Within the Ellipse	17 (100%)	13 (59%)	30
Out of the Ellipse	0 (0%)	9 (41%)	9
Total	17 (100%)	22 (100%)	39

This table shows that there are more R-R and Q-T periods out the Rejection-Ellipse in uterine cancer cases than in non-cancer gynecological patients. Consequently, it may be concluded that myocardial disorders are more frequent in uterine cancer patients than in non-cancer cases.

The correlation between the Ellipse and the advancement of uterine cancer is seen in Table IV.

TABLE IV

R-R & Q-T periods	Advancement of uterine cancer		Total
	below second stage	above third stage	
Within the Ellipse	10 (83%)	3 (30%)	13
Out of the Ellipse	2 (17%)	7 (70%)	9
Total	12 (100%)	10 (100%)	22

The data in this table suggest that the more advanced the uterine cancer, the more frequent are R-R and Q-T periods out of the Rejection Ellipse, that is, the more fequent are myocardial disorders.

Table V shows the correlation between the Ellipse and the so-called post-operative circulatory disturbances in uterine cancer cases.

TABLE V

R-R & Q-T period	So-called post-operative circulatory disturbance		Total
	not occured	occured	
Within the Ellipse	13 (100%)	0 (0%)	13(100%)
Out of the Ellipse	3 (43%)	4 (57%)	7(100%)
Total	16	4	20

We see that the uterine cancer patients whose R-R and Q-T periods are pre-

operatively out of the Rejection-Ellipse are liable to show post-operative circulatory disturbances. Thus, the Rejection-Ellipse for the R-R and Q-T periods is helpful to prognosticate post-operative circulatory conditions in uterine cancer cases pre-operatively.

Summary

Having calculated the "Rejection-Ellipse" for the R-R and Q-T periods of the E. C. G., the author proposed a new statistical procedure to judge the myocardial functions so as to find myocardial disorders. Its application in the gynecological clinic has revealed that myocardial disorders are more frequent in uterine cancer patients than in gynecological non-cancer cases, and that the more advanced the uterine cancer, the more frequent are myocardial disorders. This "Rejection Elllpse" is helpful to prognosticate the post-operative circulatory conditions in uterine cancer cases pre-operatively.

References

1) Bickenbach, W. : Ein einfaches Verfahren zur Prüfung der Kreislaufperipherie vor der Operation. *Zbl. f. Gyn.*, Nr. **29** : 1570–1581, 1938.

2) Masuyama, M. : Jikkenkeikakuho Taiyo. Gakujyutsutoshoshuppansha, Tokyo, 1950. Masuyama, M. : Shosurei no Matomekata to Jikkenkeikaku no Tatekata. Kawadeshobo, Tokyo, 1949.