

# The U Wave of the Electrocardiogram†

GROUP CAPTAIN S. KRISHNAMURTI\* & MAJOR C. M. KHANNA\*\*

THE U-wave is the small, usually positive deflection occurring in the electrocardiogram (ECG), after the T-wave. It has received scant attention probably because of its small size, infrequent occurrence and paucity of knowledge regarding its genesis and significance.

The U-wave, not exceeding 0.5 mm in height, is seen commonly in lead II. It occurs 0.02-0.04 sec. after the T-wave; its duration does not exceed 0.2 sec. and its polarity is the same as that of the preceding T-wave. In the chest leads, it is tallest in  $V_2$ - $V_4$ , bearing the same polarity and not exceeding 50% of the height of the companion T-wave. It is not seen if the heart rate exceeds 90/mt. In a combined ECG-phonocardiogram, the U-wave usually begins soon after the S2 and reaches a peak coincident with S3. When encountered, it often poses a problem as to whether it is normal or abnormal or an artifact.

Search of the literature has failed to reveal any reports of this wave of the ECG from India. The most comprehensive and largest study of the U-wave has been that of Lepeschkin<sup>1, 2, 3</sup>. In view of the above, a study was undertaken with a view to—

- determine the incidence of the U-wave in 1500 consecutive ECGs taken in a large hospital (AFMC/CH-SC)
- study the morphological features and voltage characteristics, and
- assess the effect of exercise on this wave.

## Material and Method

1500 consecutive ECG's recorded over a period of approximately three years were taken up for analysis. The ECGs belonged either to cases admitted to hospital or out-patient referrals. The ECGs comprised of 14 leads, including IIR and

aVFR; they were taken with all the usual precautions on the supine subject, about 1½ hours after the last meal. The records were made at a paper speed of 25 mm per second on either a Cardiomat-Seimens, or a Cardiopan-Phillips.

After recording, the ECG's were divided into 'Normals' i.e. no disease was present or suspected, and 'Abnormals' when CVS or other system disease was detected; all of them were studied in detail. 100 normals, whose ECGs showed unequivocally U-waves in more than one lead, were selected to study the effects of exercise. Because of familiarity and ease of conduction, Master Double-2 step exercise<sup>4</sup> was chosen and the procedure was carried out personally by one of the authors. The serum potassium was also determined in 50 of these cases.

## RESULTS

### Incidence

The 1500 ECGs comprised of 927 "Normals" and 573 "Abnormals". 33% (525) of the ECGs showed the presence of U-waves. (Fig 1) Consider-

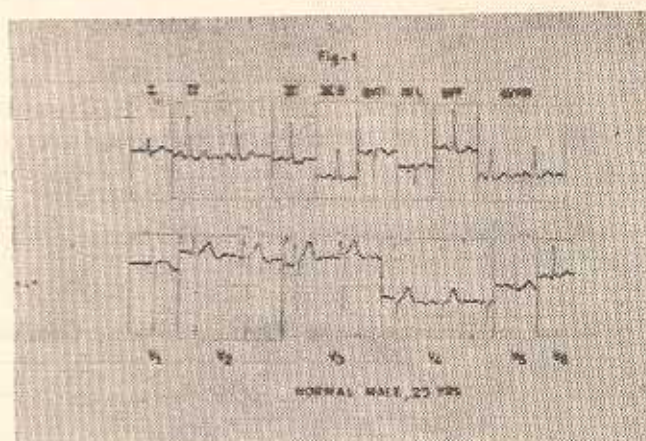


Fig. 1

† Department of Medicine  
\* Associate Professor of Medicine  
\*\* Graded Physician

ARMED FORCES  
MEDICAL COLLEGE,  
PUNE-1

ring the two groups separately, the incidence of U-waves in the "Normals" was 27% (251) and in the "Abnormals" 47% (274).

#### Age and Sex Distribution

Age (Yrs.)	NORMALS (Nos.)		ABNORMALS (Nos.)	
	Males	Females	Males	Females
21-30	317	56	202	75
31-40	175	37	62	36
41-50	102	28	46	30
51-60	93	28	44	20
61+	78	13	48	10
Total	765	162	402	171

The majority of subjects in both the groups were between the ages of 21 and 50 years. The sex ratio however was not identical, being M:F::4:1 in the "Normals" and in the "Abnormals" M:F::2:1. (NB: This kind of a situation always arises whenever a military population is studied).

#### Incidence of U-Waves in the "Normals" & Abnormals" and their Age & Sex Distribution

Age (Yrs.)	NORMALS (Nos.)		ABNORMALS (Nos.)	
	Male	Female	Male	Female
21-30	80	17	94	16
31-40	44	10	49	11
41-50	26	10	35	15
51-60	26	8	30	10
61+	22	8	8	6
Total	198	53	216	58

In the "Normals", the incidence of U-waves was not significantly different in various age groups and the two sexes. On the other hand, the incidence of U-waves in the "Abnormals" is definitely high (53%); especially in men of age group 21-50 have a high incidence (47%).

#### Incidence of U-waves in the Various Disease Groups

Disease	Total	Nos with U-waves	%
<b>I CARDIOVASCULAR</b>			
a. Hypertensive	100	74	74
b. Ischaemic	68	35	50
c. Rheumatic	66	27	48
d. Congenital	20	5	25
e. Cardiomyopathy	12	2	16

Disease	Total	Nos with U-waves
<b>II NON CARDIOVASCULAR</b>		
a. Intracranial disorders	50	25
b. Viral hepatitis	85	46
c. Chronic renal diseases	21	8
d. Pain chest — NYD	68	25
<b>III MISCELLANEOUS</b>	85	37

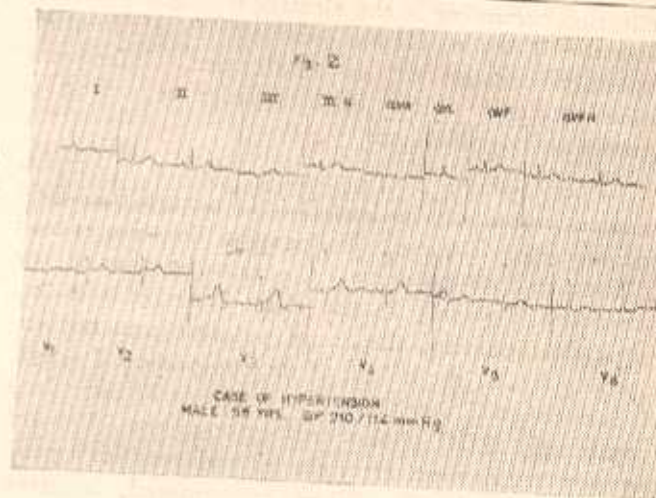


Fig. 2

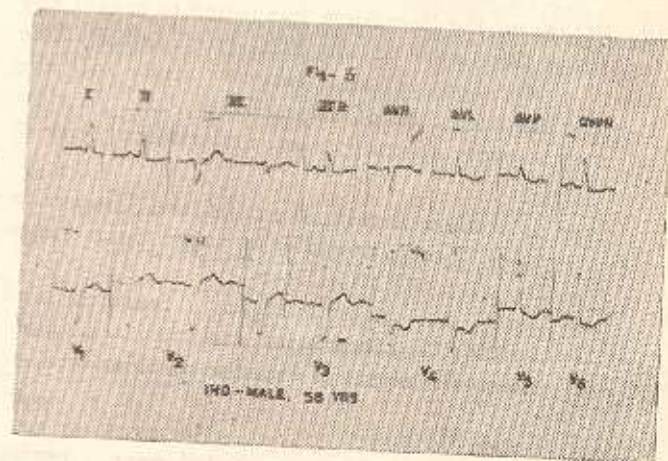


Fig. 3

Hypertension was associated with the maximum incidence of prominent U-waves (74%); none of these were on treatment at the time of ECG evaluation. (Fig 2) Next in order was IHD (50%). (Fig 3) Incidence in the case of other CVS diseases varied between 16 — 48%. (Fig 4)

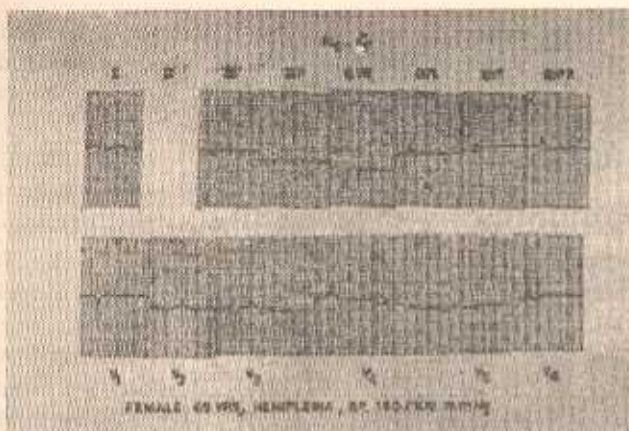


Fig. 4

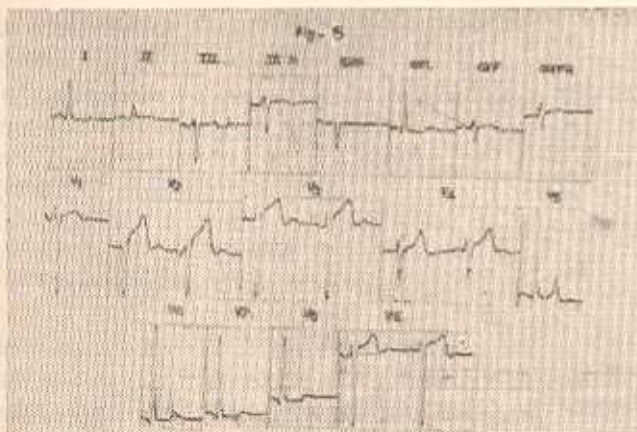


Fig. 5

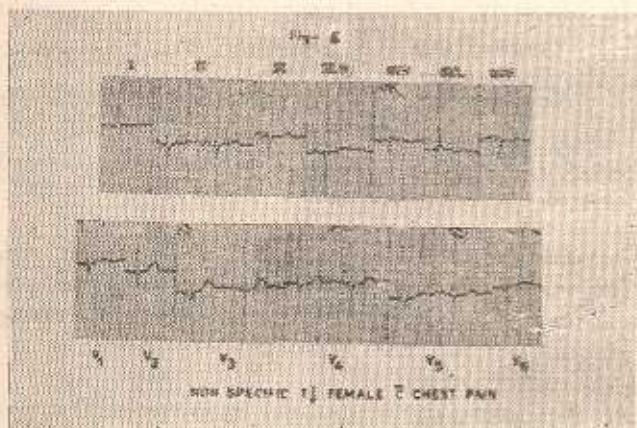


Fig. 6

Non-cardiac conditions like intracranial disorders (Fig 5) including cerebrovascular lesions, renal diseases without any appreciable changes in serum

$K^+$  and viral hepatitis also were associated with incidence of prominent U-waves. (Fig 6)

A group of 68 subjects being evaluated for "NYD — Chest Pain" showed a 37% incidence of U-waves; none of these were found to be suffering any detectable disease anywhere, including CVS. (Fig 7)

100 males (age group 21 to 50 yrs), who showed prominent U-waves in the resting ECG and were normal clinically and biochemically, were given exercise (Master, Double-2-Step) and the post exercise ECG's were recorded 5 mts after exercise and analysed for the U-wave in particular and IHD in general.

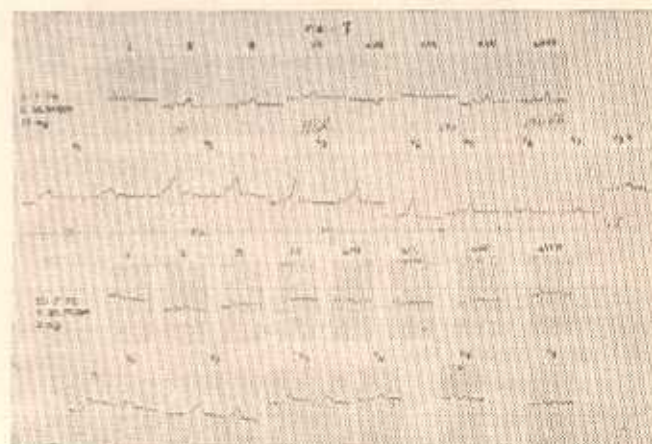


Fig. 7

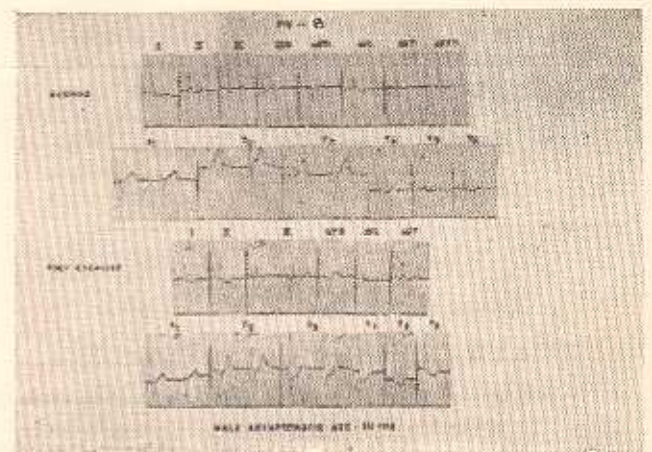


Fig. 8

After exercise all showed tachycardia (Fig 8) 8 cases produced ST depression more than 1.0 mm. In 24, the U-wave amplitude increased by 50% of the resting value; these patients were in the 21-30 yr. age group. There was one case of post-exercise U-wave inversion. (Fig. 9)

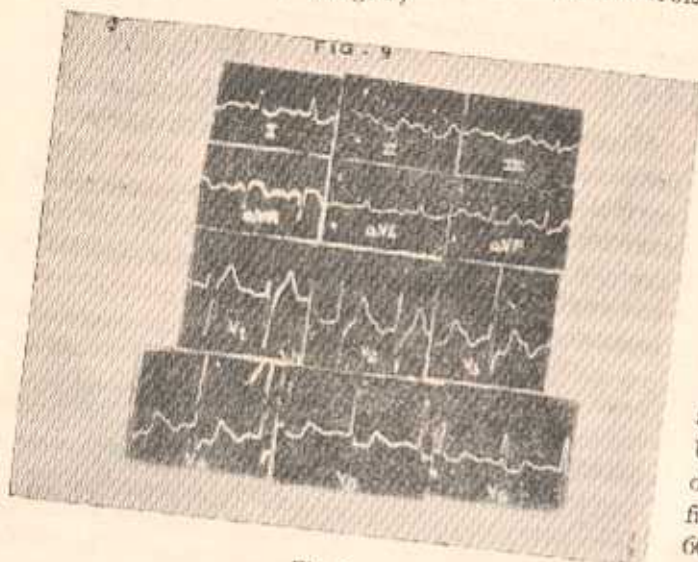


Fig. 9

Nature of change	Total cases	+ve
Increased U-wave amplitude	91	24
ST depression (1mm)	100	8
U-wave inversion	100	1

Serum potassium levels were studied in 50 "Normals", with prominent U-waves. The results were:

Serum K+ (mEQ/L)	No. of cases
2.0 - 2.5	9
2.6 - 3.0	
3.1 - 3.5	
	10
3.6 - 4.0	32
4.1 - 4.5	8
4.6 - 5.0	6
	4
	18

As expected and as is well known, U-waves were seen in 64% of cases with  $K^+ < 3.5$  mEQ/L.

### Discussion

Nearly 60% of the cases studied by Le had U-waves<sup>1,2,3</sup>. He further noted that exceeded 0.5 mm in amplitude in hardly our study, the incidence of U-waves is 35% and in those who were "Normal" it is 27% and sex made no difference in this group. Far as the voltage criteria are concerned, we U-waves exceeding 1.0 mm only in the chest in 24 cases; in the rest our observations were similar to that reported by Lepschkin and others<sup>5,6</sup>.

In the "abnormals", we noted an incidence of 53%; in males (47%). We also found prominent U-waves a feature of all types of cardiovascular disorders.<sup>7</sup> In this series, hypertension leads to a field with 74%. Male hypertensives between 41-60 years invariably showed prominent U-waves especially if the diastolic exceeded 110 mm. There were 44 such cases. None of the hypertensives showed negative U-waves as reported by others.<sup>8</sup>

Incidence of U-waves in IHD is well documented in the literature<sup>9,10</sup>. It is usually elevated in the acute phase of the disease; later it may remain upright, preceded by an inverted T or vice versa. In a small proportion of cases, it may remain permanently inverted, even after the Q has disappeared. In this study, we found prominent but only upright U-waves in 35 out of 68 cases (50%).

We also noted U-waves in cases with ventricular enlargement of diverse aetiology, viz. rheumatic, congenital and cardiopathic. 21 cases of LVH and 13 of RVH had prominent U-waves (45%).

The positive U-waves in 37% of cases seen with chest pain, who on further examination and investigation had no detectable disease, raises interesting possibilities but defies reasonable explanation.

U-waves are not unusual in intracranial disorders<sup>11</sup>. Our incidence of 50% comprises of cases of subarachnoid haemorrhage, meningitis, cerebral thrombosis and closed head injuries.

Another interesting but unusual feature we come across was the presence of U-waves in 46 out

of 85 cases of viral hepatitis. Further scrutiny revealed direct relationship between the height of the U-wave and the level of serum bilirubin. The U-wave which was well seen at the peak of jaundice started losing amplitude as serum bilirubin levels declined and in the majority, the U-wave disappeared by the time of discharge of the patient. In these cases we found no other metabolic or other abnormalities to account for either the appearance or the disappearance of the U-wave. To say that it was merely due to the slow heart rate seen usually in viral hepatitis seems too simple an explanation, for all cases did not have U-waves and no correlation between pulse rate, bilirubin level and presence of U-waves could be established, try as we may. We do not think this phenomenon has so far been reported in medical literature and recommend further detailed study.

Exercise induced tachycardia of the expected degree in all the cases. In 8, we noted ST depression of a diagnostic order. In only one case the U-wave became negative after exercise. According to Phillips<sup>9</sup>, a negative U-wave during or after exercise signifies IHD, even if no other abnormalities are detected. In 24 cases the amplitude of the U-wave increased by more than 50%. Often after exercise the U-wave is noted for the first time in the chest leads, particularly V<sub>1</sub> to V<sub>4</sub> or an earlier U-wave becomes more prominent<sup>12</sup>. Many reasons are given for these occurrences; change in blood pH, effect of hyperventilation, movement of K<sup>+</sup> out of the myocardium are some of them.

#### Conclusions

From this study of 1500 ECG's, consisting of 927 "Normals", and 573 "abnormal" an overall incidence of the presence of U-waves is found to be 35%.

The U-wave occurs in 27% of the "Normal" Indian population. A higher incidence of 53% is noted in disease states.

74% of hypertensives and 50% of IHD cases

had prominent U-waves, followed by intracranial lesions and viral hepatitis. The occurrence of U-waves in 52% of cases of viral hepatitis, maximally at the height of jaundice and its disappearance on recovery, is probably being reported for the first time.

U-waves seen in the resting ECG may be indicative of occult IHD; 8 such cases produced a positive post-exercise ECG and 1 case had post-exercise negative U-wave.

Lastly, prominent U-waves may be the early, if not the only sign of low serum K<sup>+</sup> as noted in 64% of cases in this study.

#### REFERENCES:

1. LEPESCHKIN, E., The U-wave of the ECG. *Arch. Int. Med.* 96, 600, 1955.
2. LEPESCHKIN, E., Genesis of the U-wave. *Circulation*, 15, 77, 1957.
3. LEPESCHKIN, E., The U-wave of the ECG. *Mod. Conc. in Card. Vas. Dis.* 39, 45, 1969.
4. MASTER, A.M. The Master 2-Step Test. *Amer. Ht. J.* 75, 809, 1968.
5. FRIEDBERG, C.K. *Diseases of the Heart*, III Edn. W.B. Saunders Co. Philadelphia: 1966.
6. LIPMAN, B.S. & MASSIE, E. *Clinical Scalar Electrocardiography*. IV Edn. The Year Book. Pub. Inc., Chicago; 1959.
7. NAHUM, I.H. & HOFF, N.E. The interpretation of the U-wave of the ECG. *Amer. Ht. J.* 17, 585, 1939.
8. FURBETTA, D., BUFALARI & SANTUCCI. Abnormality of the U-wave and of the T-U segment. *Circulation*, 14, 1129, 1956.
9. PHILLIPS, J.H., DEPASQUADE, N.P. & BURCH, G.E. ECG in infarction of antero-lateral papillary muscle. *Amer. Ht. J.* 66, 338, 1963.
10. PAPP, C. U-wave in coronary disease. *Circulation*, 15, 005, 1957.
11. EISALE, A., PERSALE, J., HALOMAR, P.I. ECG abnormalities in Sub arachnoid haemorrhage. *Brit. Med. J.* 34, 217, 1972.
12. PAPP, C. The sixth wave of the ECG. *Brit. Ht. J.* 2, 9, 1940.