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Krause & Pachernegg GmbH · VERLAG für MEDIZIN und WIRTSCHAFT · A-3003 Gablitz/Austria

ORIGINAL PAPERS, BASIC CARDIOLOGY

Designing Nomogram for Determining the Heart's QRS Axis

S. S. Hoseini[1], A. Moeeny[2], S. Shoar[1, 3], N. Shoar[4], M. Naderan[1], S. H. Gharibzadeh[5], A. R. Dehpour[3]

Background: Electrocardiogram is a recording of the heart's electrical activity which could be very informative in the approach to patients with cardiac or non-cardiac problems. Determining the electrical axis of the heart (mainly QRS complex axis) is the first step in interpreting the electrocardiogram of a patient and has important applications in both clinical and epidemiological studies. Aim: This study was performed to design a nomogram for the exact determination of the heart's QRS axis. Settings and Design: We used the corrected formula to determine the heart's QRS axis. Materials and Methods: In order to calculate the electrical axis of the heart in the frontal plane, we used the combination of leads I and aVF. We used MATLAB m-code programming to design the nomogram according to the corrected formula. Results: Our work is a nomogram which uses leads I and aVF to calculate the heart's electrical QRS axis. This nomogram covers the mean QRS complex between –30 and +30 small squares. Conclusion: This recording helps in the long-term assessment of physiological axis changes during treatment and follow-up. By means of this nomogram, the effects of pathological factors on the heart's axis could be evaluated more accurately. ***J Clin Basic Cardiol 2011; 14 (online): 12–5.***

Key words: *heart axis, nomogram, QRS*

The recording of the heart's electrical activity (ECG) and its interpretation are among the first steps in the approach to a patient with cardiovascular signs and symptoms. The electrical pulse usually originates in the sinoatrial node traveling through the atria to the atrioventricular node and then down the bundle of His, bundle branches, and fascicular pathways to the ventricles. The mean axis of the P, QRS, and T waves or ST segment can be determined; however, the overall direction of the heart's axis is mostly related to QRS [1]. The normal range of the heart's axis is between –30° and +90° [2]. Available methods to determine the heart's axis, like "at a glance" and "quadrant-and-degree", which mostly use leads I and aVF, could not exactly determine the electrical axis [3–5] and to date, there is no easy way for accurate determination of heart's electrical axis. For clinical and epidemiological purposes, precise determination of the axis is important. In this article, we design a nomogram for exact and fast calculation of the heart's electrical axis, which may be used as a first diagnostic tool in cardiovascular medicine.

Material and Methods

In order to calculate the electrical axis of the heart in the frontal plane, any combination of 2 of the leads could be used, but leads I and aVF have advantages over other pairs [1, 6].

The procedure for determination of the heart's axis based on the QRS complex using a drawing method is as follows (Figure 1):

1) Plot the net deflection of the QRS complex (mean QRS) for leads I and aVF on the axes related to each of them (Figure 1a).
2) Run perpendicular lines from each of the plotted points for these 2 leads (Figure 1b).
3) The point of intersection of perpendicular lines (Z point) represents the apex of the mean QRS axis in ventricles (Figure 1c).
4) Draw a vector between the intersection of the axes (O point) and the apex of vector, Z point. The angle between lead I and OZ vector is the angle of heart electrical axis (Figure 1d).

Simple trigonometry helps calculate α as a function of aVF and I voltages:

$$\alpha = Arctg(\frac{aVF}{I})$$

This formula is sometimes used for heart's axis calculation, but it is inaccurate [7]. The inaccuracy is caused by the difference in the electrical strength of aVF, which is a bipolar lead, and lead I, which is a unipolar lead. There is a modification to correct this problem by adding a correlation factor to the equation:

$$\alpha = Arctg(\frac{2}{\sqrt{3}} \times \frac{aVF}{I})$$

Vector determination has great importance in epidemiological studies and in the long-term follow-up of patients [8, 9]. So we used the corrected formula to design our heart's axis determination charts (nomogram).

We used MATLAB m-code programming to generate the values of α for different combinations of aVF and I voltages commonly seen in clinical practice.

Results

Our work shown in the Appendix is a 2-part nomogram which uses leads I and aVF for calculating the heart's electrical axis. This nomogram covers the mean QRS complex between –3 and +3 mV (–30 to +30 small squares).

Conclusion

In this manuscript, we introduce a nomogram for the exact calculation of the mean QRS electrical axis (as the heart's electrical axis) using the voltage of leads I and aVF. We recommend physicians, nurses, and other medical technicians to use this nomogram to calculate the heart's axis and save it

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From the [1]Development Association of Clinical Studies (DACS), Student Scientific Research Center (SSRC), Tehran University of Medical Sciences, Tehran, Iran; [2]Laboratory of Sensorimotor Research, National Eye Institute, National Institutes of Health, Bethesda, USA; [3]Department of Pharmacology, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran; [4]Shahid Beheshti Hospital, Kashan University of Medical Sciences, Kashan, Iran; [5]Neuromuscular Systems Laboratory, Faculty of Biomedical Engineering, Amirkabir University of Technology, Iran.
Correspondence to: Saeed Shoar, MD, Development Association for Clinical Study (DACS), Student Scientific Research Center (SSRC), Tehran University of Medical Sciences (TUMS), No 54, Boostan e Qods (Shilat) Dormitory, Shahed Alley, Qods Street, Keshavarz Boulevard, Tehran, Iran; e-mail: saaedshoar@gmail.com

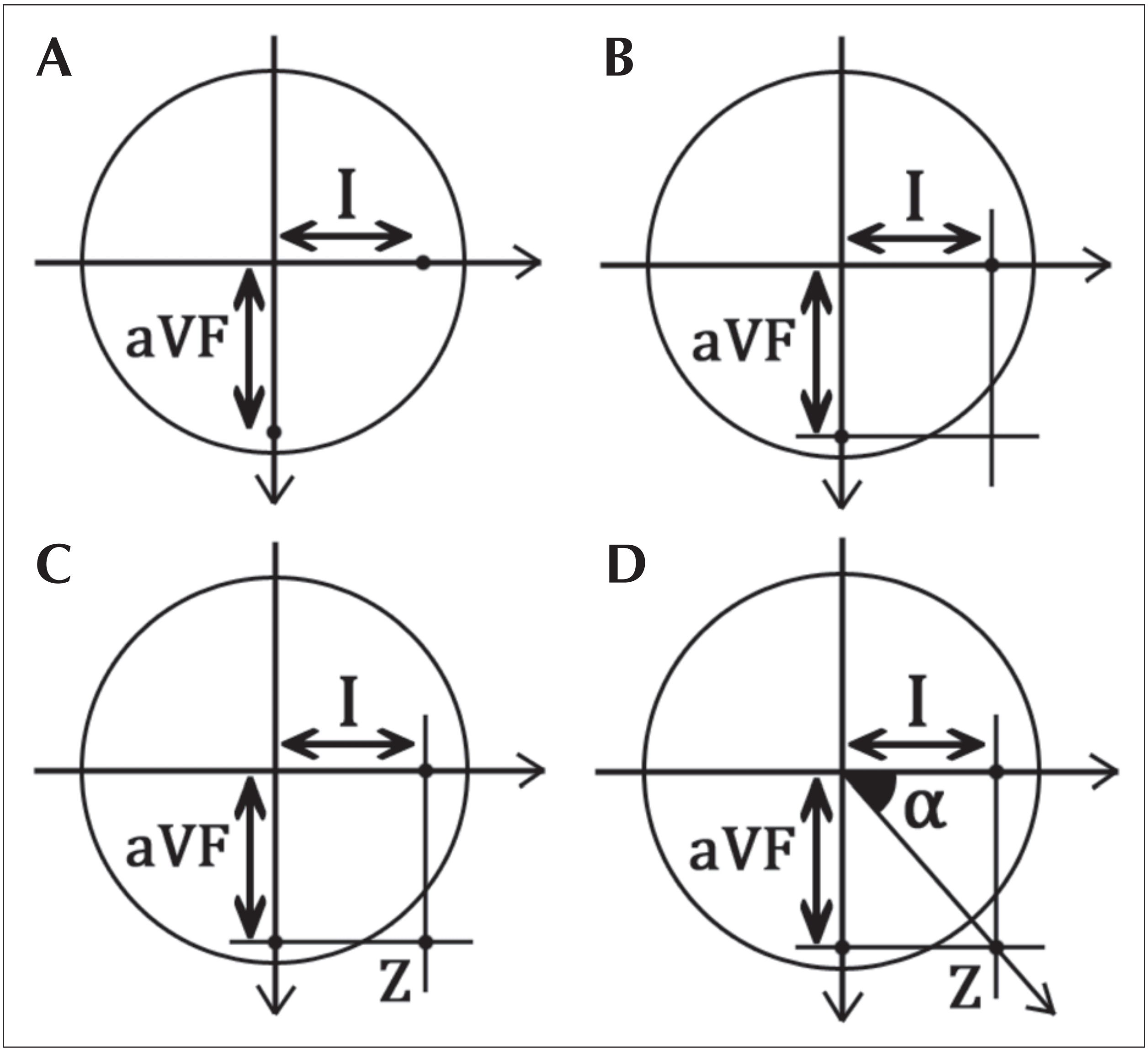

Figure 1. The drawing method for determination of the heart axis using the QRS complex. **(a)** Plot the net deflection of QRS complex (mean QRS) for both leads I and aVF along each lead; **(b)** Run perpendicular lines from each of the plotted points; **(c)** Z point represents the apex of the mean QRS axis; **(d)** Draw a vector between O point and Z point. The angle between lead I and OZ vector is the angle of the heart's electrical axis.

in the patient's medical records. This recording helps to have a long-term assessment of the physiological changes of the axis during the course of treatment or follow-up. In addition, by using this nomogram, the effects of pathological factors on the heart's axis could be evaluated more accurately.

We proposed that the rate of heart axis change over time could be an index for disease severity, progression, and efficacy of therapy. Accordingly, there is a wide range for a normal heart axis (–30° to +90°) and it is better to follow the alterations of the axis over time than to claim that it is in the normal range or not.

These proposed advantages could be achieved by simply using the nomogram presented.

Conflict of Interest

The authors have no conflict of interest to declare.

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Appendix – Table 1. Two-part nomogram that uses leads I and aVF for calculating the heart's electrical axis.

	Lead I																													
Lead aVF	**-30**	**-29**	**-28**	**-27**	**-26**	**-25**	**-24**	**-23**	**-22**	**-21**	**-20**	**-19**	**-18**	**-17**	**-16**	**-15**	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
-30	-131	-130	-129	-128	-127	-126	-125	-124	-122	-121	-120	-119	-117	-116	-115	-113	-112	-111	-109	-108	-106	-105	-103	-101	-100	-98	-97	-95	-93	-92	-90
-29	-132	-131	-130	-129	-128	-127	-126	-124	-123	-122	-121	-120	-118	-117	-116	-114	-113	-111	-110	-108	-107	-105	-103	-102	-100	-98	-97	-95	-93	-92	-90
-28	-133	-132	-131	-130	-129	-128	-127	-125	-124	-123	-122	-120	-119	-118	-116	-115	-113	-112	-110	-109	-107	-106	-104	-102	-101	-99	-97	-95	-94	-92	-90
-27	-134	-133	-132	-131	-130	-129	-128	-126	-125	-124	-123	-121	-120	-119	-117	-116	-114	-113	-111	-109	-108	-106	-104	-103	-101	-99	-97	-95	-94	-92	-90
-26	-135	-134	-133	-132	-131	-130	-129	-127	-126	-125	-124	-122	-121	-120	-118	-117	-115	-113	-112	-110	-108	-107	-105	-103	-101	-99	-98	-96	-94	-92	-90
-25	-136	-135	-134	-133	-132	-131	-130	-129	-127	-126	-125	-123	-122	-120	-119	-117	-116	-114	-113	-111	-109	-107	-105	-104	-102	-100	-98	-96	-94	-92	-90
-24	-137	-136	-135	-134	-133	-132	-131	-130	-128	-127	-126	-124	-123	-122	-120	-118	-117	-115	-113	-112	-110	-108	-106	-104	-102	-100	-98	-96	-94	-92	-90
-23	-138	-138	-137	-135	-134	-133	-132	-131	-130	-128	-127	-126	-124	-123	-121	-119	-118	-116	-114	-112	-111	-109	-107	-105	-103	-101	-99	-96	-94	-92	-90
-22	-140	-139	-138	-137	-136	-135	-133	-132	-131	-130	-128	-127	-125	-124	-122	-121	-119	-117	-115	-113	-111	-110	-107	-105	-103	-101	-99	-97	-95	-92	-90
-21	-141	-140	-139	-138	-137	-136	-135	-133	-132	-131	-130	-128	-127	-125	-123	-122	-120	-118	-116	-114	-112	-110	-108	-106	-104	-102	-99	-97	-95	-92	-90
-20	-142	-141	-140	-139	-138	-137	-136	-135	-134	-132	-131	-129	-128	-126	-125	-123	-121	-119	-117	-115	-113	-111	-109	-107	-105	-102	-100	-97	-95	-92	-90
-19	-144	-143	-142	-141	-140	-139	-138	-136	-135	-134	-132	-131	-129	-128	-126	-124	-123	-121	-119	-117	-115	-112	-110	-108	-105	-103	-100	-98	-95	-93	-90
-18	-145	-144	-143	-142	-141	-140	-139	-138	-137	-135	-134	-132	-131	-129	-128	-126	-124	-122	-120	-118	-116	-113	-111	-109	-106	-104	-101	-98	-95	-93	-90
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-15	-150	-149	-148	-147	-146	-145	-144	-143	-142	-140	-139	-138	-136	-134	-133	-131	-129	-127	-125	-122	-120	-117	-115	-112	-109	-106	-103	-100	-97	-93	-90
-14	-152	-151	-150	-149	-148	-147	-146	-145	-144	-142	-141	-140	-138	-136	-135	-133	-131	-129	-127	-124	-122	-119	-116	-113	-110	-107	-104	-101	-97	-94	-90
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27	-134	-133	-132	-131	-130	-129	-128	-126	-125	-124	-123	-121	-120	-119	-117	-116	-114	-113	-111	-109	-108	-106	-104	-103	-101	-99	-97	-95	-94	-92	90
28	-133	-132	-131	-130	-129	-128	-127	-125	-124	-123	-122	-120	-119	-118	-116	-115	-113	-112	-110	-109	-107	-106	-104	-102	-101	-99	-97	-95	-94	-92	90
29	-132	-131	-130	-129	-128	-127	-126	-124	-123	-122	-121	-120	-118	-117	-116	-114	-113	-111	-110	-108	-107	-105	-103	-102	-100	-98	-97	-95	-93	-92	90
30	-131	-130	-129	-128	-127	-126	-125	-124	-122	-121	-120	-119	-117	-116	-115	-113	-112	-111	-109	-108	-106	-105	-103	-101	-100	-98	-97	-95	-93	-92	90

Appendix – Table 1 (continued). Two-part nomogram that uses leads I and aVF for calculating the heart's electrical axis.

Lead aVF \ Lead I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
-30	88	87	85	83	82	80	79	77	75	74	72	71	69	68	67	65	64	63	61	60	59	58	56	55	54	53	52	51	50	49
-29	88	87	85	83	82	80	78	77	75	73	72	70	69	67	66	64	63	62	60	59	58	57	56	54	53	52	51	50	49	48
-28	88	86	85	83	81	79	78	76	74	73	71	70	68	67	65	64	62	61	60	58	57	56	55	53	52	51	50	49	48	47
-27	88	86	85	83	81	79	77	76	74	72	71	69	67	66	64	63	61	60	59	57	56	55	54	52	51	50	49	48	47	46
-26	88	86	84	82	81	79	77	75	73	72	70	68	67	65	63	62	60	59	58	56	55	54	53	51	50	49	48	47	46	45
-25	88	86	84	82	80	78	76	75	73	71	69	67	66	64	63	61	60	58	57	55	54	53	51	50	49	48	47	46	45	44
-24	88	86	84	82	80	78	76	74	72	70	68	67	65	63	62	60	58	57	56	54	53	52	50	49	48	47	46	45	44	43
-23	88	86	84	81	79	77	75	73	71	69	68	66	64	62	61	59	57	56	54	53	52	50	49	48	47	46	45	43	42	42
-22	88	85	83	81	79	77	75	73	70	69	67	65	63	61	59	58	56	55	53	52	50	49	48	47	45	44	43	42	41	40
-21	88	85	83	81	78	76	74	72	70	68	66	64	62	60	58	57	55	53	52	50	49	48	47	45	44	43	42	41	40	39
-20	88	85	83	80	78	75	73	71	69	67	65	63	61	59	57	55	54	52	51	49	48	46	45	44	43	42	41	40	39	38
-19	87	85	82	80	77	75	72	70	68	65	63	61	59	57	56	54	52	51	49	48	46	45	44	42	41	40	39	38	37	36
-18	87	85	82	79	76	74	71	69	67	64	62	60	58	56	54	52	51	49	48	46	45	43	42	41	40	39	38	37	36	35
-17	87	84	81	78	76	73	70	68	65	63	61	59	56	55	53	51	49	47	46	44	43	42	40	39	38	37	36	35	34	33
-16	87	84	81	78	75	72	69	67	64	62	59	57	55	53	51	49	47	46	44	43	41	40	39	38	36	35	34	33	33	32
-15	87	83	80	77	74	71	68	65	63	60	58	55	53	51	49	47	46	44	42	41	40	38	37	36	35	34	33	32	31	30
-14	86	83	79	76	73	70	67	64	61	58	56	53	51	49	47	45	44	42	40	39	38	36	35	34	33	32	31	30	29	28
-13	86	82	79	75	72	68	65	62	59	56	54	51	49	47	45	43	41	40	38	37	36	34	33	32	31	30	29	28	27	27
-12	86	82	78	74	70	67	63	60	57	54	52	49	47	45	43	41	39	38	36	35	33	32	31	30	29	28	27	26	26	25
-11	85	81	77	73	69	65	61	58	55	52	49	47	44	42	40	38	37	35	34	32	31	30	29	28	27	26	25	24	24	23
-10	85	80	75	71	67	63	59	55	52	49	46	44	42	40	38	36	34	33	31	30	29	28	27	26	25	24	23	22	22	21
-9	85	79	74	69	64	60	56	52	49	46	43	41	39	37	35	33	31	30	29	27	26	25	24	23	23	22	21	20	20	19
-8	84	78	72	67	62	57	53	49	46	43	40	38	35	33	32	30	29	27	26	25	24	23	22	21	20	20	19	18	18	17
-7	83	76	70	64	58	53	49	45	42	39	36	34	32	30	28	27	25	24	23	22	21	20	19	19	18	17	17	16	16	15
-6	82	74	67	60	54	49	45	41	38	35	32	30	28	26	25	23	22	21	20	19	18	17	17	16	15	15	14	14	13	13
-5	80	71	63	55	49	44	40	36	33	30	28	26	24	22	21	20	19	18	17	16	15	15	14	14	13	13	12	12	11	11
-4	78	67	57	49	43	38	33	30	27	25	23	21	20	18	17	16	15	14	14	13	12	12	11	11	10	10	10	9	9	9
-3	74	60	49	41	35	30	26	23	21	19	17	16	15	14	13	12	12	11	10	10	9	9	9	8	8	8	7	7	7	7
-2	67	49	38	30	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6	6	5	5	5	5	5	5	4
-1	49	30	21	16	13	11	9	8	7	7	6	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	49	30	21	16	13	11	9	8	7	7	6	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2
2	67	49	38	30	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6	6	5	5	5	5	5	5	4
3	74	60	49	41	35	30	26	23	21	19	17	16	15	14	13	12	12	11	10	10	9	9	9	8	8	8	7	7	7	7
4	78	67	57	49	43	38	33	30	27	25	23	21	20	18	17	16	15	14	14	13	12	12	11	11	10	10	10	9	9	9
5	80	71	63	55	49	44	40	36	33	30	28	26	24	22	21	20	19	18	17	16	15	15	14	14	13	13	12	12	11	11
6	82	74	67	60	54	49	45	41	38	35	32	30	28	26	25	23	22	21	20	19	18	17	17	16	15	15	14	14	13	13
7	83	76	70	64	58	53	49	45	42	39	36	34	32	30	28	27	25	24	23	22	21	20	19	19	18	17	17	16	16	15
8	84	78	72	67	62	57	53	49	46	43	40	38	35	33	32	30	29	27	26	25	24	23	22	21	20	20	19	18	18	17
9	85	79	74	69	64	60	56	52	49	46	43	41	39	37	35	33	31	30	29	27	26	25	24	23	23	22	21	20	20	19
10	85	80	75	71	67	63	59	55	52	49	46	44	42	40	38	36	34	33	31	30	29	28	27	26	25	24	23	22	22	21
11	85	81	77	73	69	65	61	58	55	52	49	47	44	42	40	38	37	35	34	32	31	30	29	28	27	26	25	24	24	23
12	86	82	78	74	70	67	63	60	57	54	52	49	47	45	43	41	39	38	36	35	33	32	31	30	29	28	27	26	26	25
13	86	82	79	75	72	68	65	62	59	56	54	51	49	47	45	43	41	40	38	37	36	34	33	32	31	30	29	28	27	27
14	86	83	79	76	73	70	67	64	61	58	56	53	51	49	47	45	44	42	40	39	38	36	35	34	33	32	31	30	29	28
15	87	83	80	77	74	71	68	65	63	60	58	55	53	51	49	47	46	44	42	41	40	38	37	36	35	34	33	32	31	30
16	87	84	81	78	75	72	69	67	64	62	59	57	55	53	51	49	47	46	44	43	41	40	39	38	36	35	34	33	33	32
17	87	84	81	78	76	73	70	68	65	63	61	59	56	55	53	51	49	47	46	44	43	42	40	39	38	37	36	35	34	33
18	87	85	82	79	76	74	71	69	67	64	62	60	58	56	54	52	51	49	48	46	45	43	42	41	40	39	38	37	36	35
19	87	85	82	80	77	75	72	70	68	65	63	61	59	57	56	54	52	51	49	48	46	45	44	42	41	40	39	38	37	36
20	88	85	83	80	78	75	73	71	69	67	65	63	61	59	57	55	54	52	51	49	48	46	45	44	43	42	41	40	39	38
21	88	85	83	81	78	76	74	72	70	68	66	64	62	60	58	57	55	53	52	50	49	48	47	45	44	43	42	41	40	39
22	88	85	83	81	79	77	75	73	70	69	67	65	63	61	59	58	56	55	53	52	50	49	48	47	45	44	43	42	41	40
23	88	86	84	81	79	77	75	73	71	69	68	66	64	62	61	59	57	56	54	53	52	50	49	48	47	46	45	43	42	42
24	88	86	84	82	80	78	76	74	72	70	68	67	65	63	62	60	58	57	56	54	53	52	50	49	48	47	46	45	44	43
25	88	86	84	82	80	78	76	75	73	71	69	67	66	64	63	61	60	58	57	55	54	53	51	50	49	48	47	46	45	44
26	88	86	84	82	81	79	77	75	73	72	70	68	67	65	63	62	60	59	58	56	55	54	53	51	50	49	48	47	46	45
27	88	86	85	83	81	79	77	76	74	72	71	69	67	66	64	63	61	60	59	57	56	55	54	52	51	50	49	48	47	46
28	88	86	85	83	81	79	78	76	74	73	71	70	68	67	65	64	62	61	60	58	57	56	55	53	52	51	50	49	48	47
29	88	87	85	83	82	80	78	77	75	73	72	70	69	67	66	64	63	62	60	59	58	57	56	54	53	52	51	50	49	48
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