Role of Implantable Loop Recorder in the Evaluation of Syncope

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Definition & Mechanism of Syncope

- Transient loss of consciousness accompanied by loss of postural tone with rapid onset and spontaneous recovery
- Abrupt and brief interruption of cerebral blood flow to reticular activating system in brain stem

Clinical Significance of Syncope

- Common cardiac symptom
- Sometimes misdiagnosed as seizure
- Can be premonitory sign of cardiac arrest
- Can have major impact on lifestyle, physically or mentally
- Can cause injury or traffic accident
- Expensive in terms of the cost for syncope evaluation

Neurally-mediated (reflex)
- Vasovagal syncope (common faint)
  - classical
  - non-classical
- Carotid sinus syncope
- Situational syncope
  - acute haemorrhage
  - cough, sneeze
  - gastrointestinal stimulation (swallow, defaecation, visceral pain)
  - micturition (post-micturition)
  - post-exercise
  - post-prandial
  - others (e.g., brass instrument playing, weightlifting)
- Glossopharyngeal neuralgia

Orthostatic hypotension
- Autonomic failure
  - primary autonomic failure syndromes (e.g., pure autonomic failure, multiple system atrophy, Parkinson's disease with autonomic failure)
  - secondary autonomic failure syndromes (e.g., diabetic neuropathy, amyloid neuropathy)
  - post-exercise
  - post-prandial
- Drug (and alcohol)-induced orthostatic syncope
- Volume depletion
  - Haemorrhage, diarrhoea, Addison's disease

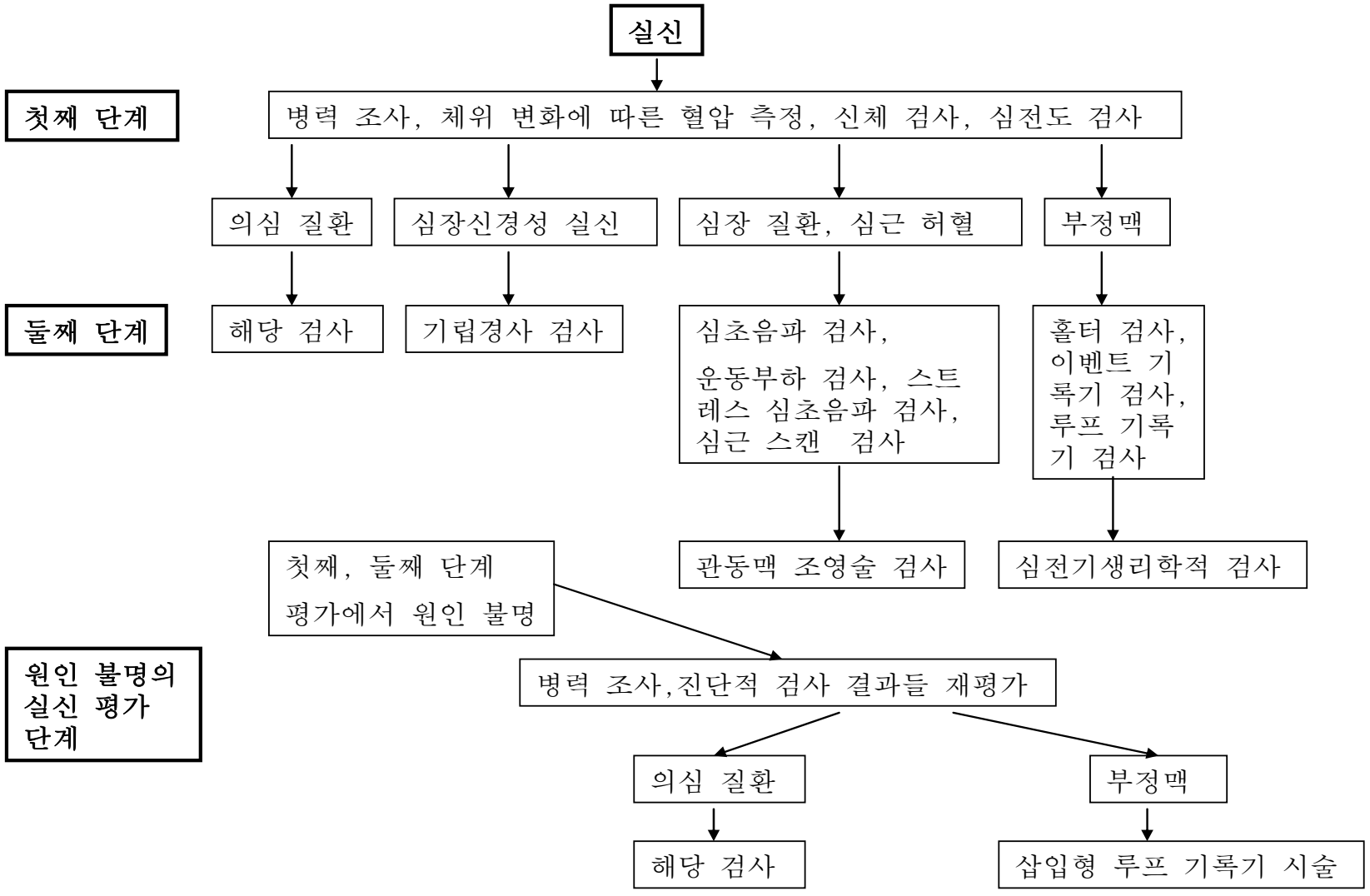
Cardiac Arrhythmias as primary cause
- Sinus node dysfunction (including bradycardia/tachycardia syndrome)
- Atrioventricular conduction system disease
- Paroxysmal supraventricular and ventricular tachycardias
- Inherited syndromes (e.g., long QT syndrome, Brugada syndrome)
- Implanted device (pacemaker, ICD) malfunction
- Drug-induced proarrhythmias

Structural cardiac or cardiopulmonary disease
- Obstructive cardiac valvular disease
- Acute myocardial infarction / ischaemia
- Obstructive cardiomyopathy
- Atrial myxoma
- Acute aortic dissection
- Pericardial disease/tamponade
- Pulmonary embolus / pulmonary hypertension

Cerebrovascular
- Vascular steal syndromes

(Brignole et al. Eur Heart J 2004;25:2054-72)

실신 환자의 실신 원인 진단 과정



(최윤식, 이영우. 순환기학, 제 2판. 일조각, pp. 525~531)

Unexplained syncope after initial evaluation

- There is still a high unexplained syncope rate after initial diagnostic evaluation in patient with syncope.
  - 37% in general population
  - 17 ~ 33% in emergency department
  - 5 ~ 20% in syncope unit

Table 3. Comparison of the Causes of Syncope between the ED and OPD Groups

	Total (n=104)	ED (n=41)	OPD (n=63)	*p* value
Final diagnosis				
Neurally mediated	59 (55.7)	20 (48.8)	39 (61.9)	0.187
Orthostatic	15 (14.2)	9 (22.0)	6 (9.5)	0.078
Arrhythmia	3 (2.8)	0	3 (4.8)	0.277
Structural cardiac	4 (3.8)	3 (7.3)	1 (1.6)	0.298
Cerebrovascular	1 (0.9)	1 (2.4)	0	0.394
Unexplained syncope	22 (20.8)	8 (19.5)	14 (22.2)	0.741
Days for diagnosis (median, IQR)	25 (3-41)	4 (1-28)	35 (17-44)	<0.001
Number of tests performed	5.6±1.9	6.2±1.7	5.3±2.0	0.012

ED, emergency department; OPD, outpatient department; IQR, interquartile ranges.

Data are presented as n (%) or mean±SD or interquartile ranges.

(Kang et al. Yonsei Med J 2012;53:517-23)

Table 4. Patterns and Results of Diagnostic Tests in Syncope Evaluation (n=104)

Tests performed	Frequency (%)	Abnormal result (%)	Diagnostic yield (%)
Postural BP check	33 (31.7)	15 (45.5)	5 (15.2)
Blood test	87 (83.7)	39 (44.8)	5 (5.7)
ECG	103 (99.0)	28 (27.2)	1 (1.0)
Echocardiography	62 (59.6)	14 (22.6)	2 (3.2)
HUTT	82 (78.8)	53 (64.6)	50 (61.0)
Carotid sinus massage	1 (0.9)	0 (0)	0 (0)
Holter recording	45 (43.3)	17 (37.8)	3 (6.7)
EPS	7 (6.7)	3 (42.9)	1 (14.3)
CAG	6 (5.8)	3 (50)	2 (33.3)
TMT	32 (30.8)	5 (15.6)	1 (3.1)
Stress echocardiography	0 (0)	0 (0)	0 (0)
EEG	9 (8.7)	2 (22.2)	0 (0)
Brain CT	25 (24.0)	7 (28.0)	1 (4.0)
Brain MRI & MRA	19 (18.2)	6 (31.5)	0 (0)
Carotid Doppler	4 (3.8)	1 (25)	0 (0)
CXR	62 (59.6)	8 (12.9)	0 (0)
ILR	0 (0)	0 (0)	0 (0)

BP, blood pressure; ECG, electrocardiogram; HUTT, head-up tilt test; EPS, electrophysiologic study; CAG, coronary angiography; TMT, treadmill test; CT, computerized tomography; MRI, magnetic resonance imaging; MRA, magnetic resonance angiography; CXR, chest X-ray; ILR, implantable loop recorder; EEG, electroencephalography.

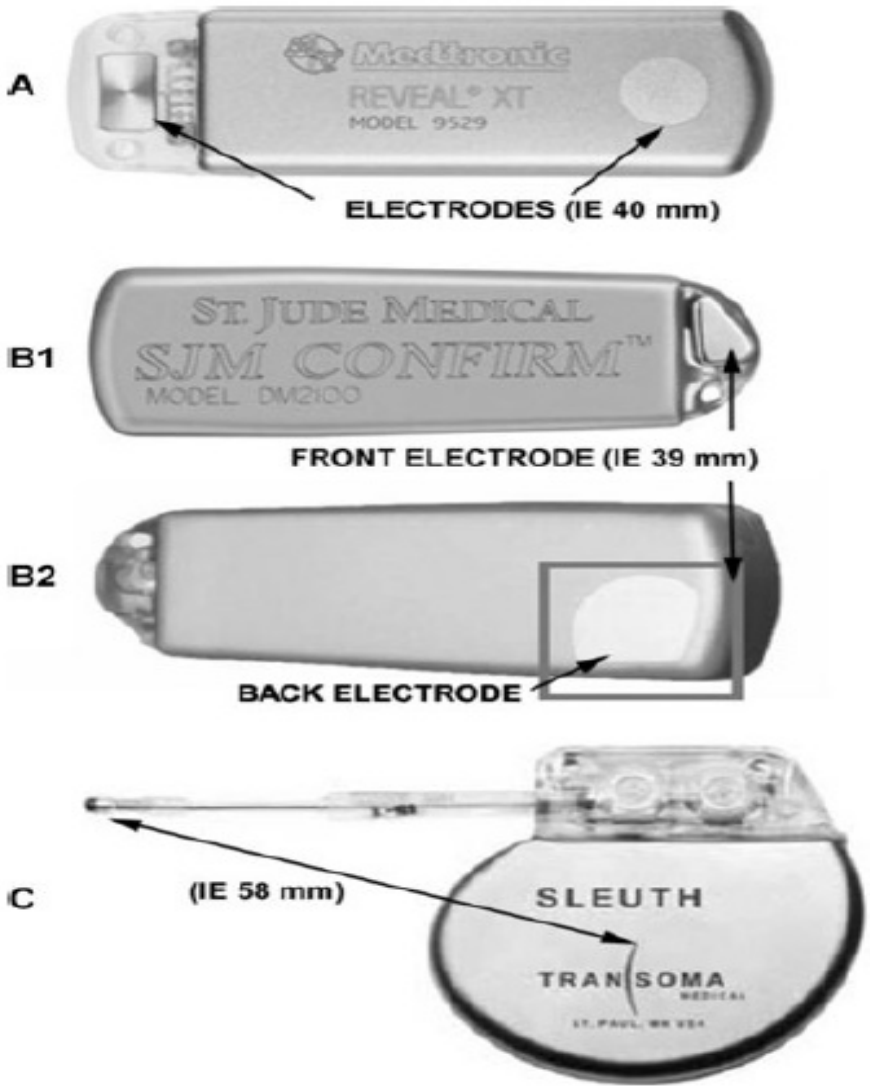
(Kang et al. Yonsei Med J 2012;53:517-23)

Implantable loop recorder (ILR)

- Valuable diagnostic tool in recurrent unexplained syncope following negative initial evaluation, where an arrhythmic cause is suspected.
- Small ECG monitoring device implanted in the subcutaneous tissue of the left chest .
- Records a bipolar ECG signal at the time of symptoms by a handheld activator or at the occurrence of arrhythmia by a programmed automatic detection recognition.
- Battery longevity; 1 ~ 3 years
- Recently, wireless ILR is introduced.

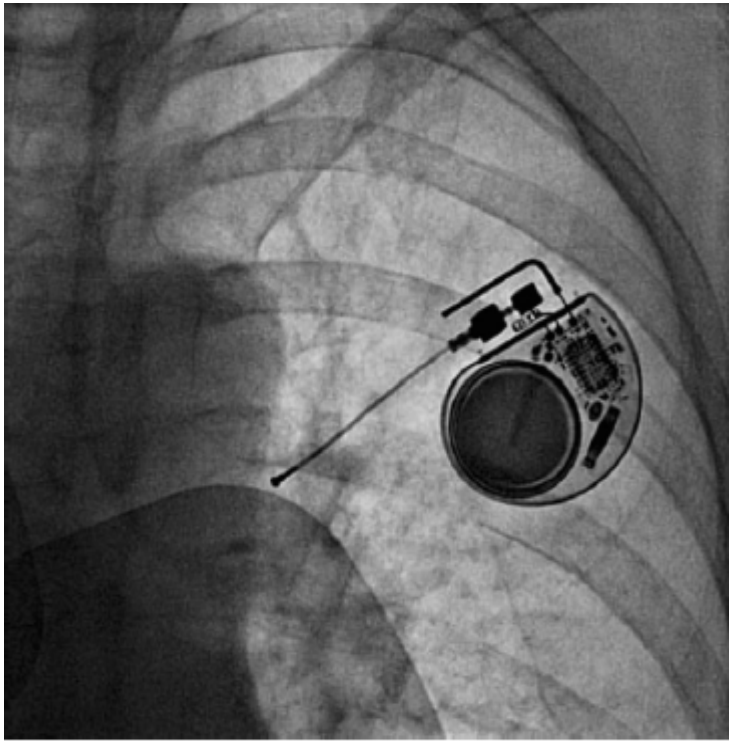
Types of ILR

- Medtronic Inc.
  - Reveal ®, Reveal ® Plus
  - Reveal ® Dx, Reveal ® XT (with remote monitoring)
- St. Jude Medical Inc.
  - Confirm ® ICM (with remote monitoring)
- Transoma Medical Inc.
  - Sleuth ® High-Fidelity ILR(with remote monitoring); recently discontinued by the company



(Jacob et al. PACE 2010;33:834-40)

Reveal ® Plus ILR and activator



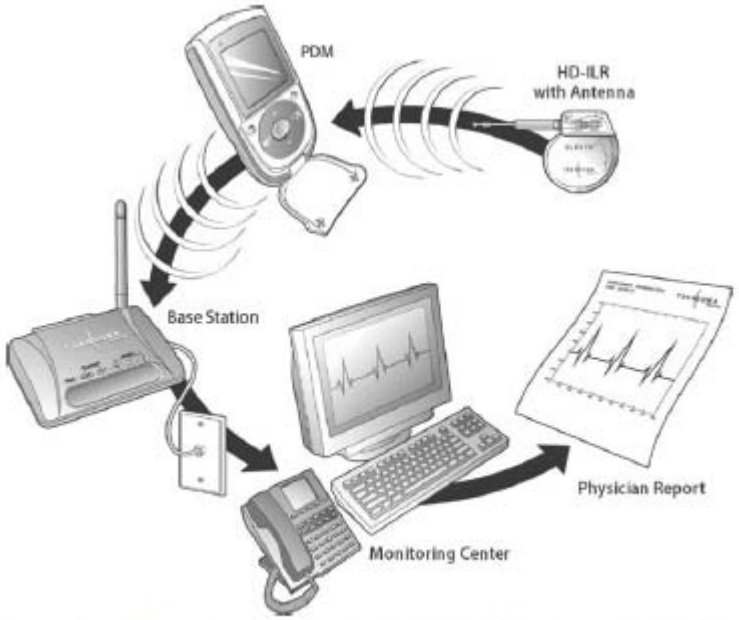


Figure 2 Schematic overview of the Sleuth ILR system. See text for discussion. ILR = implantable loop recorder; PDM = patient diagnostic manager.

(Paruchuri et al. Heart Rhythm 2011;8:858-63)

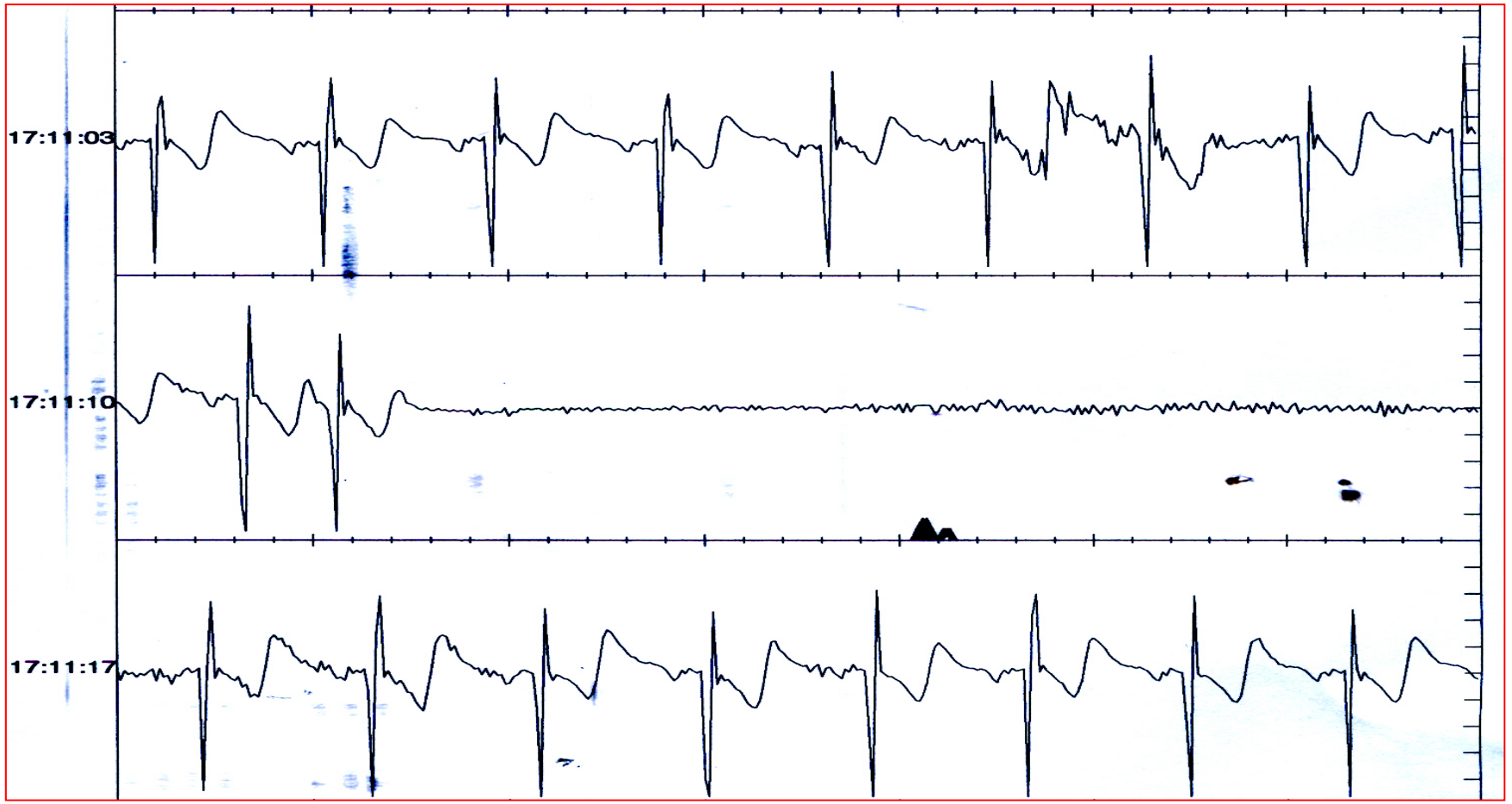
Indications of ILR

- **Class I**
  - An early phase of evaluation in patients with recurrent syncope of uncertain origin, absence of high risk criteria which require prompt hospitalization or intensive evaluation, and a high likelihood of recurrence within battery longevity of the device
  - High risk patients in whom a comprehensive evaluation did not demonstrate a cause of syncope or lead to a specific treatment

- **Class IIa**
  - Assess the contribution of bradycardia before embarking on cardiac pacing in patients with suspected or certain reflex syncope presenting with frequent or traumatic syncopal episodes.

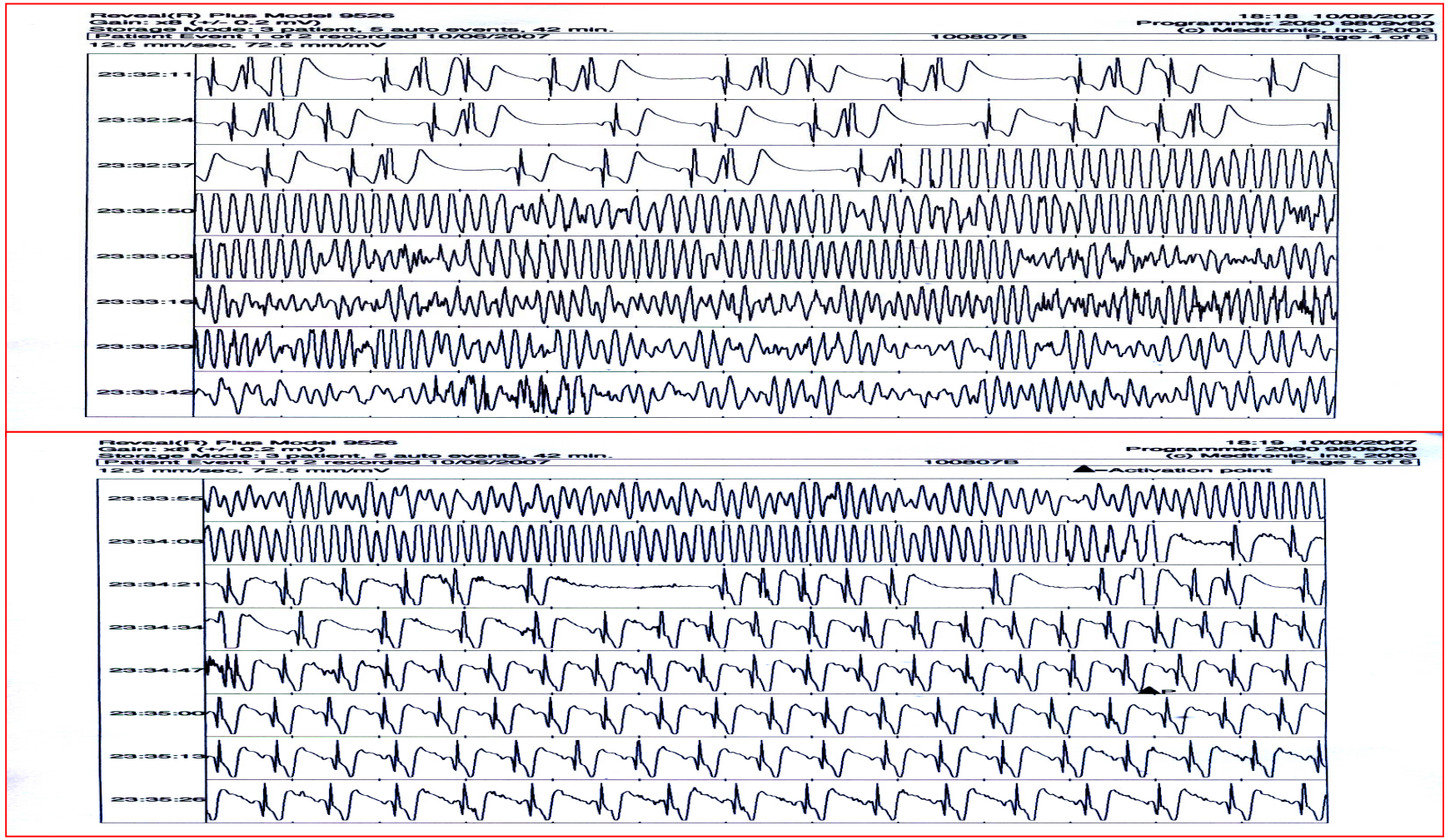
(Moya et al. Guidelines for the diagnosis and management of syncope (version 2009). Eur Heart J. 2009;30:2631-71)

Pause shown in tracings downloaded from ILR



(Shin et al. Korean Circ J 2008;38:205-211)

VT/VF shown in tracings downloaded from ILR

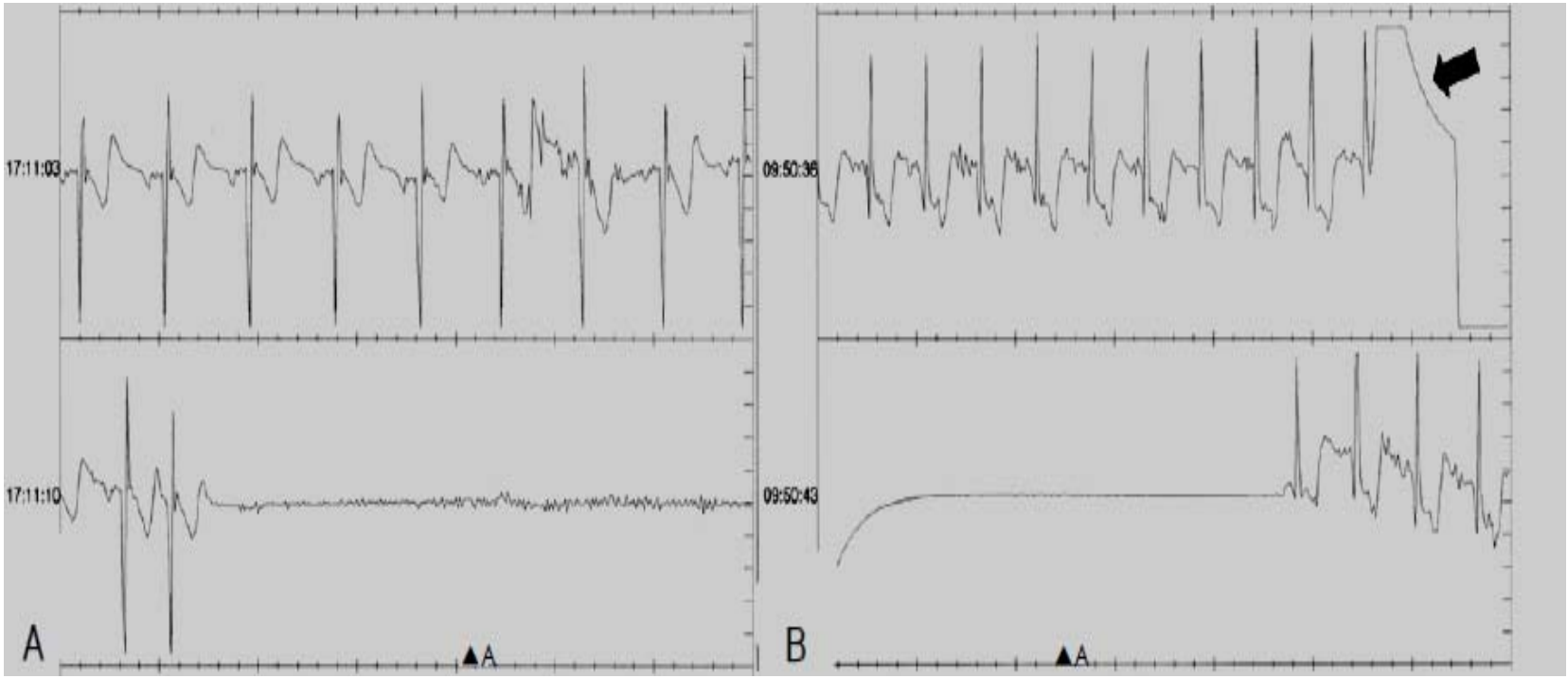


(Shin et al. Korean Circ J 2008;38:205-211)

Technical limitations of ILR

- Pseudopause
- Undersensing of signals
- Oversensing of signals
- Noise
- Limited storage capacity
  - Overwrite clinically significant arrhythmic events with ECG storage of events triggered by a sensing abnormality.

True pause Pseudo pause

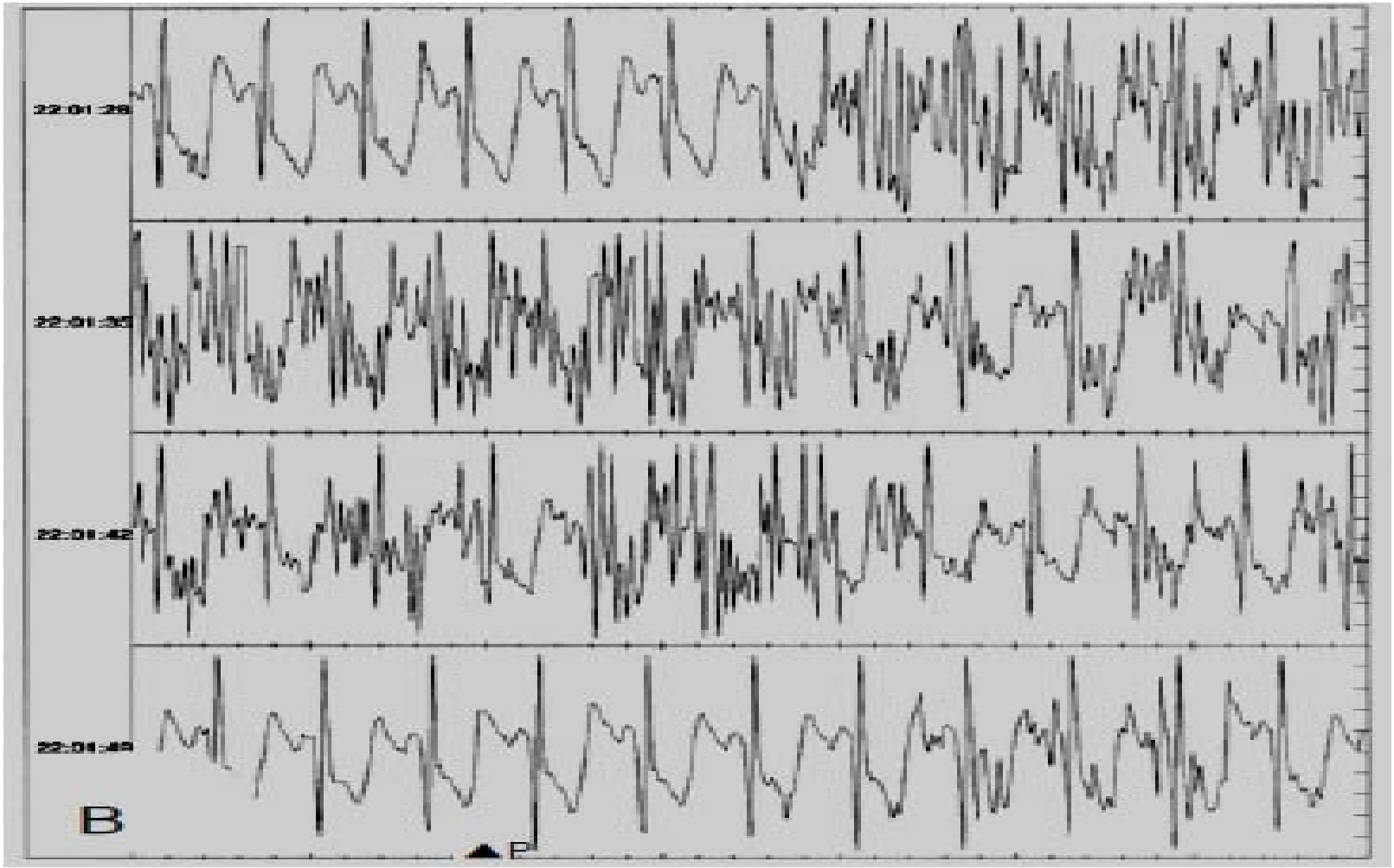


(Shin et al. Korean Circ J 2008;38:205-211)

Undersensing of ECG signals

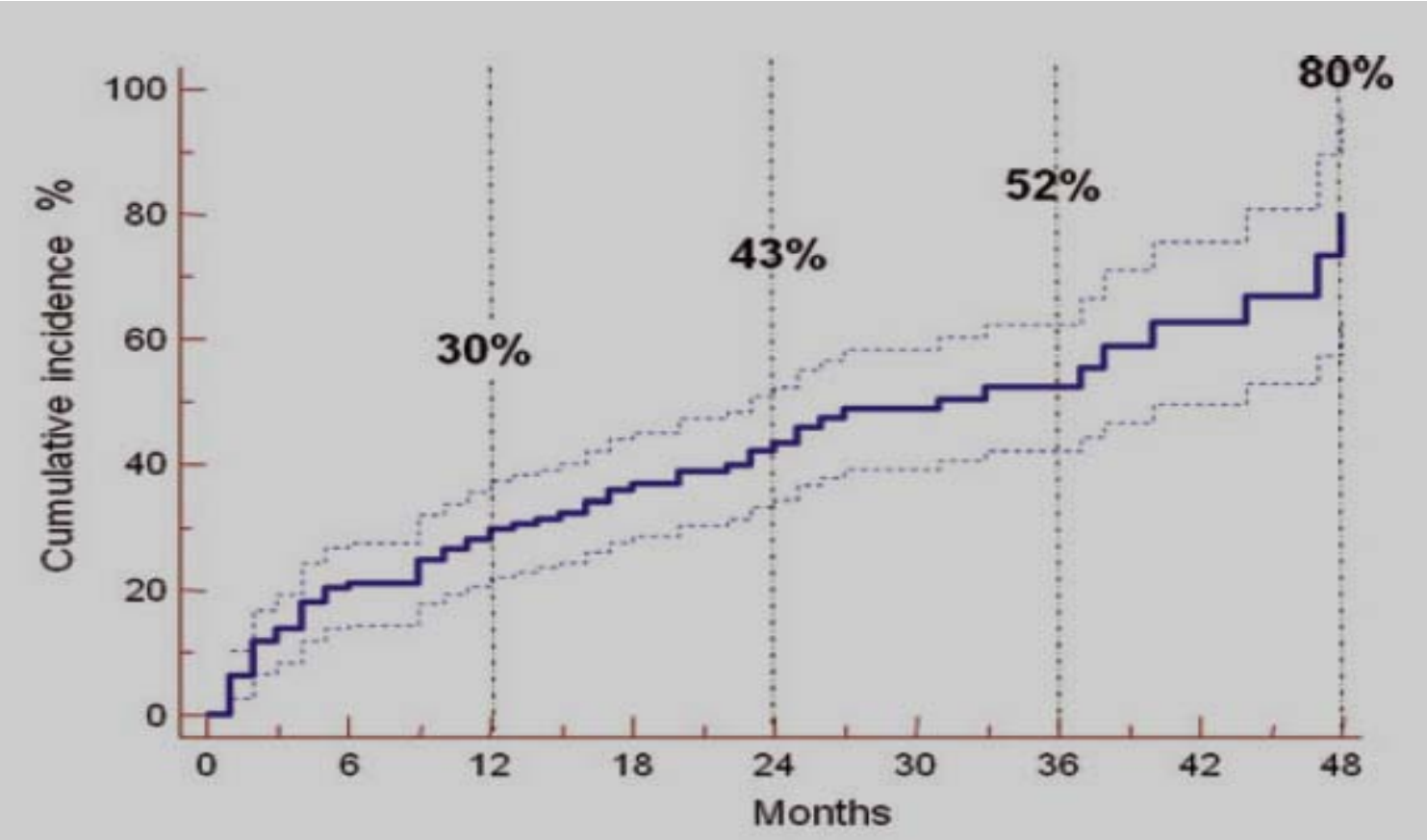
(Shin et al. Korean Circ J 2008;38:205-211)

Oversensing of ECG signals due to artifact



(Shin et al. Korean Circ J 2008;38:205-211)

Time-dependent cumulative diagnostic yield of ILR



(Furukawa et al. JCE 2012;23:67-71)

The clinical utility of ILR in the evaluation of Korean patient with unexplained syncope

Methods

- Study population
  - 18 patients with recurrent syncope whose diagnosis remained unexplained despite a through initial evaluation at Samsung Medical Center
- Period
  - June 2006 ~ June 2011
- Types of ILR
  - Reveal ® Plus, Medtronic Inc.;12
  - Reveal ® Dx, Medtronic Inc. ; 2
  - Confirm ® ICM St. Jude Medical, Inc. ; 4

Results

Clinical characteristics of study patients

Clinical parameters	Value
No. of patients	18
Age (years)	61 ± 15
Male gender	13 (72%)
Underlying disease	
Hypertension	5 (28%)
Coronary artery disease	5 (28%)
None	5 (28%)
Hypertrophic cardiomyopathy	4 (22%)
Diabetes mellitus	3 (17%)
Dilated cardiomyopathy	1 (6%)
Prior stroke	1 (6%)

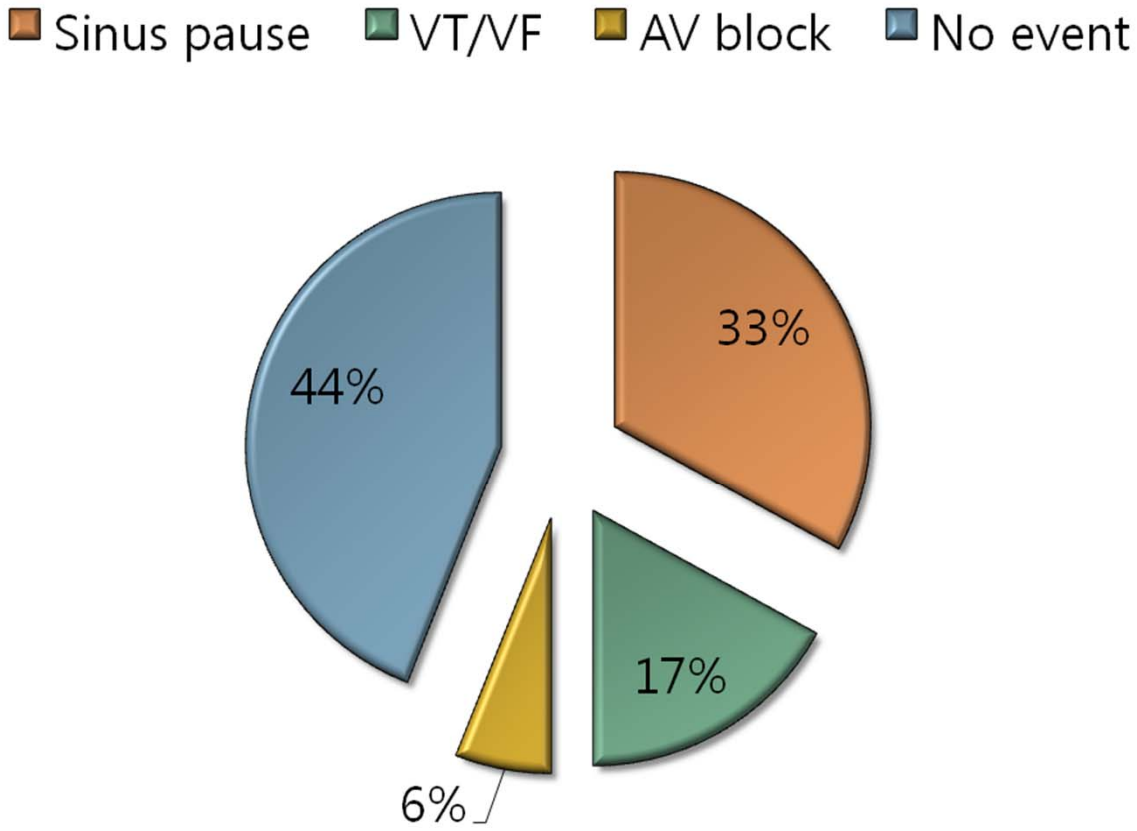
(Unpublished data)

Diagnostic tests performed before ILR implantation

Diagnostic tests	Value
No. of patients	18
Tilt table testing	14 (78%)
Electrophysiologic study	14 (78%)
Ambulatory ECG monitoring	11 (61%)
Coronary angiography	8 (44%)
Treadmil exercise testing	6 (33%)

(Unpublished data)

Types of diagnosed arrhythmias from ILR during follow-up period



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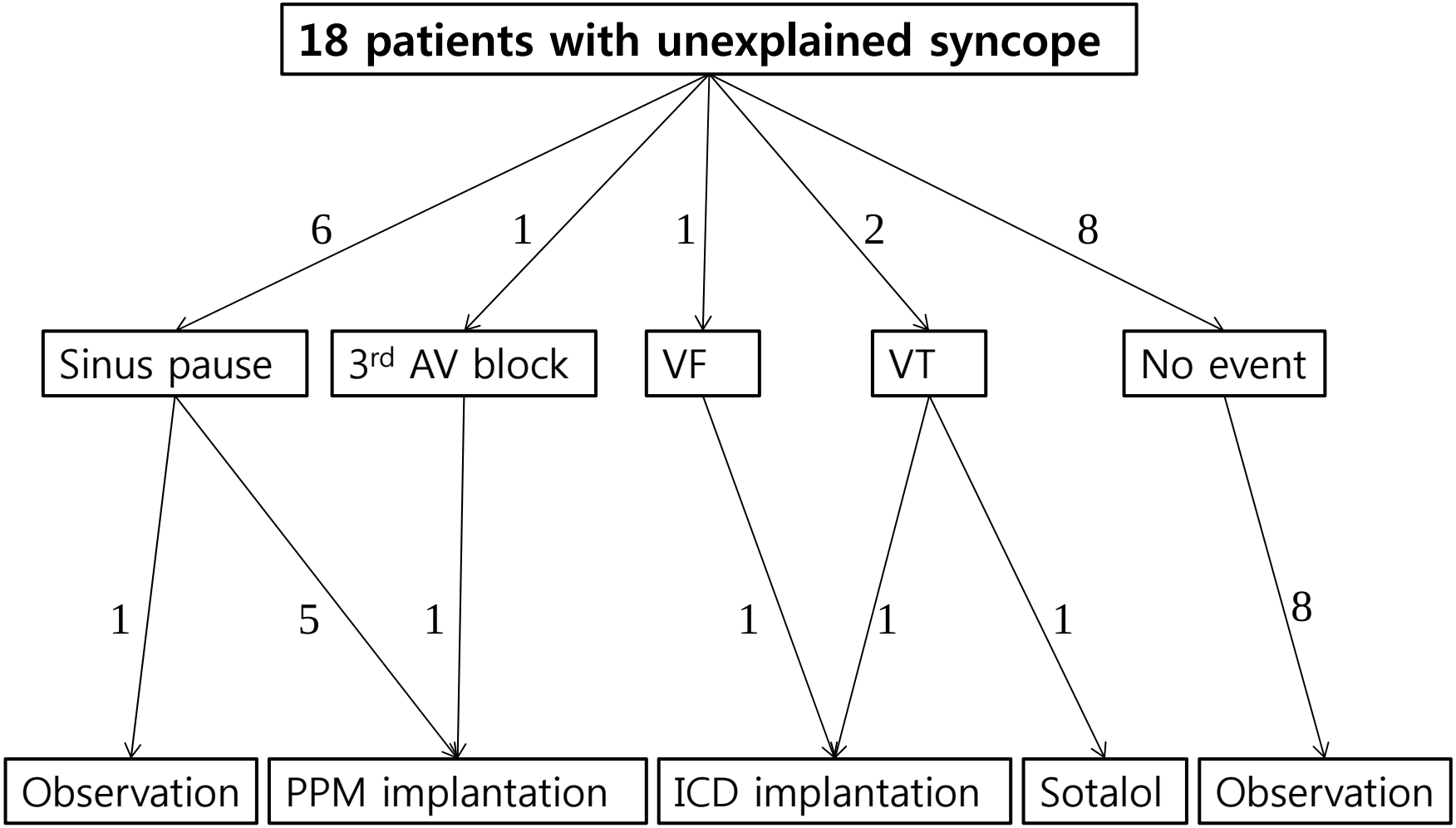

(Unpublished data)

Conclusions

- The implantable loop recorder (ILR) is a useful diagnostic tool in recurrent unexplained syncope following negative initial evaluation.
- However, ILR is still underused as a diagnostic tool in syncope evaluation in Korea.