to the total flow in the pulmonary artery. The volume passing through the SSV-ASD was calculated indirectly (32 mL/beat: shunt–SVC–PAPVD). Finally, determination of the systemic flow (71 mL/beat, 5.02 L/min) allowed calculation of the pulmonary to systemic blood flow ratio (Qp:Qs) = 2.

4D-flow CMR was equally vital for adequate evaluation after the corrective surgery, and the excellent results obtained are illustrated in figure 2. In patient 2, diagnosed with PAPVD and SSV-ASD (figure 2A-C and video 1 of the supplementary data), the postsurgery 4D-flow CMR results revealed optimal redirection of the pulmonary venous drainage (corrected pulmonary vein) to the interior of the left atrium. The analysis also confirmed the absence of interatrial flow at the level of the repaired ASD in the interatrial septum (figure 2B,C). In patient 1, diagnosed with PAPVD with no associated septal defect, postsurgery 4D-flow CMR revealed appropriate correction and redirection of drainage to the left ventricle through the interatrial septum (artificial ASD) (figure 2D-F and video 2 of the supplementary data). Neither patient showed evidence of velocity aliasing that would indicate stenosis of the corrected pulmonary vein, and both patients had a normalized postsurgery Qp:Qs ratio = 1.

4D-flow CMR, unlike standard 2D phase contrast CMR modalities, allows the assessment of arterial and venous flows in any of the 3 spatial dimensions through multiplane reconstruction of the acquired 3-dimensional volume. This ability is highly advantageous in decision-making on the treatment of simple or complex congenital heart defects both before and after surgical or percutaneous correction of the defect.[4] The temporal resolution of CMR combined with the full coverage of the cardiac cycle (the fourth dimension in 4D-flow CMR) together permit excellent color visualization of flow patterns. Together with other advantages, such as the simultaneous assessment of anatomy and function and scan acquisition during free breathing, these features make 4D-flow CMR an essential tool for the routine assessment of these types of patients.

FUNDING

AUTHORS' CONTRIBUTIONS

J. Urmeneta Ulloa: diagnosis, planning, CMR postprocessing, and manuscript writing. J. Rivas Oyarzabal: surgical treatment of patients. J.A. Cabrera: manuscript supervision. A. Álvarez Vázquez: diagnosis, planning, CMR postprocessing. A. Forteza Gil: surgical treatment of patients. V. Martínez de Vega: diagnosis, planning, CMR postprocessing, and manuscript supervision.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

APPENDIX. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version available at https://doi.org/10.1016/j.rec.2021.05.016

Javier Urmeneta Ulloa,[a,b,c,*] Jorge Rivas Oyarzabal,[d] José Ángel Cabrera,[a,b] Ana Álvarez Vázquez,[b,e] Alberto Forteza Gil,[d] and Vicente Martínez de Vega[b,e]

[a]Departamento de Cardiología, Hospital Universitario Quirónsalud, Madrid, Spain
[b]Universidad Europea de Madrid, Madrid, Spain
[c]Instituto Chileno de Imagen Cardíaca (INCIC), Santiago de Chile, Chile
[d]Departamento de Cirugía Cardiaca, Hospital Universitario Quirónsalud, Madrid, Spain
[e]Departamento de Radiología, Hospital Universitario Quirónsalud, Madrid, Spain

[*] Corresponding author:
E-mail address: javierurmeneta@hotmail.com (J. Urmeneta Ulloa).

REFERENCES

1. Baumgartner H, De Backer J, Babu-Narayan SV, et al. 2020 ESC Guidelines for the management of adult congenital heart disease: The Task Force for the management of adult congenital heart disease of the European Society of Cardiology (ESC). *Eur Heart J.* 2021;42:563–645.
2. Urmeneta Ulloa J, Álvarez Vázquez A, Martínez de Vega V, Cabrera JA. Evaluation of cardiac shunts with 4 D Flow cardiac magnetic resonance: Intra- and interobserver variability. *J Magn Reson Imaging.* 2020;52:1055–1063.
3. Azarine A, Garcon P, Stansal A, et al. Four-dimensional flow MRI: principles and cardiovascular applications. *Radiographics.* 2019;39:632–648.
4. Jimeno Sánchez J, López Ramón M, Sánchez-Recalde Áaue. Percutaneous treatment of a surgical complication of sinus venosus atrial septal defect. *Rev Esp Cardiol.* 2021. http://dx.doi.org/10.1016/j.rec.2020.12.016.

Usefulness of a smartphone-based event recorder for ambulatory patients with palpitations

Utilidad de un registrador de eventos vinculado al teléfono móvil de pacientes con palpitaciones

To the Editor,

Palpitations are a frequent reason for cardiology consultation (10%-15%).[1] The AliveCor KardiaMobile recorder (AliveCor, United States) is a device linked to a smartphone application that can perform a 30-second electrocardiogram (ECG). This device has proven useful for screening for atrial fibrillation (with 92% sensitivity and 95% specificity)[2]; however, there are few studies on its usefulness in the management of patients with palpitations. The aim of our study was to assess the diagnostic yield of the AliveCor KardiaMobile device in unselected patients with palpitations referred to the cardiology department.

From September 2018 to October 2020, we retrospectively included consecutive patients with palpitations referred to the

Table 1

Characteristics of the sample according to electrocardiographic findings

Variables	Total sample (n = 152)	Arrhythmias		P
		Yes (n = 31)	No (n = 121)	
Age, y	42 ± 15	47 ± 15	40 ± 14	.032
Women	103 (68)	23 (74)	80 (66)	.391
History				
Hypertension	29 (19)	6 (19)	23 (19)	.965
Diabetes mellitus	4 (2.6)	0 (0)	4 (3.3)	.582
Dyslipidemia	30 (20)	7 (23)	23 (19)	.656
Smoking	40 (26)	8 (26)	32 (26)	.942
Ischemic cardiomyopathy	1 (0.7)	0 (0)	1 (0.8)	.999
Heart failure	2 (1.4)	1 (3.2)	1 (0.8)	.296
Atrial fibrillation	10 (6.6)	3 (9.7)	7 (5.8)	.427
Anxiety	22 (14.5)	7 (23)	15 (12.4)	.149
Depression	8 (5.3)	4 (13)	4 (3.3)	.212
Mixed anxiety and depression disorder	5 (3.3)	0 (0)	5 (4.1)	.999
Risk factors for palpitations				
*Heart history	4 (2.6)	2 (6.5)	2 (1.7)	.185
Clinical profile	9 (5.9)	3 (9.7)	5 (4.1)	.207
Recurrent	150 (99)	31 (100)	119 (98)	.999
Physical examination	1 (0.7)	0 (0)	1 (0.8)	.999
Electrocardiogram	10 (6.6)	4 (13)	6 (5)	.121
Monitoring time, d	17 ± 8.2	16 ± 4.4	17 ± 8.9	.796

Data are expressed as No. (%) or mean ± standard deviation.

  * Heart history: family history of sudden cardiac death, ischemic heart disease, severe valvular heart disease, left or right ventricular dysfunction, significant congenital heart disease, severe pulmonary hypertension, wearing a cardiac device; clinical profile: frequent and disabling symptoms during effort; associated chest pain, syncope, or dyspnea; physical examination: organic murmur. ECG: left ventricular hypertrophy in patients younger than 50 years or without hypertension, complete right or left bundle branch block, pathological Q waves, negative T waves in precordial leads, pre-excitation, Brugada pattern, prolonged QTc (> 450 ms), frequent atrial/ventricular extrasystoles.

cardiology department with, after initial assessment, an indication for this device. Inclusion criteria were as follows: recurrent palpitations (more than 1 episode per week) lasting more than 1 minute, absence of syncope, owning a compatible smartphone, and skill in using the device. We analyzed the clinical variables and ECG recordings obtained. Electrocardiographic recordings were interpreted during consultation by the cardiologist as part of routine clinical practice. Binary logistic regression was used to assess the predictors of palpitations of arrhythmic origin. A P value of < .05 was used as cutoff for statistical significance. All analyses were conducted using the SPSS v20 software package. The study was conducted according to good clinical practice guidelines and the Declaration of Helsinki and adhered to the standards of the ethics committee of our hospital.

During the study period, 2109 patients attended 3300 consultations for palpitations (2549 face-to-face and 751 remote). Of these patients, the ECG recorder was used in 161 (9.4%), monitoring was performed in 96.8% (n = 156), and the recorder was not used in 3.2% (n = 5) due to incompatibility problems with the smartphone or a lack of skills. Of the 156 patients who used the recorder, 4 were excluded because the recording results were unavailable: thus, the final sample consisted of 152 patients. Mean age was 42 ± 15 years and 68% were women. Median delay until beginning monitoring was 5 [2-8] days and mean monitoring time was 17 ± 8.2 days. Most of the patients did not have heart disease and about 25% had a history of depression, anxiety, or both (table 1).

Monitoring showed that 31 patients (20%) had arrhythmias coincident with symptoms, 82 (54%) had no arrhythmias coincident with symptoms, and 39 (26%) had no symptoms during the recording period. The electrocardiographic abnormalities are shown in table 2.

Palpitations of arrhythmic origin were more common in older than in younger patients (table 1). Age was the only independent predictor of palpitations of arrhythmic origin (odds ratio/y = 1.03; 95% confidence interval, 1.01-1.06; P = .035).

Device yield was close to 75% for diagnosing patients referred to the cardiology department for palpitations who had remained undiagnosed after the initial assessment. Palpitations of arrhythmic origin were found in 20% of the patients and potentially dangerous arrhythmias were detected in 2.5%. These results differ from those reported by Reed et al.,[3] who described a lower yield (55%) in patients assessed in the emergency department for palpitations or syncope, despite a longer monitoring period (90 days). Furthermore, significantly fewer palpitations of arrhythmic origin were found in their series (8.9%) than in our study. These differences may be due to the exclusion of patients

Table 2

Electrocardiographic findings from the ECG device linked to the smartphone application

Type of finding, No.	109
Sinus rhythm	52 (33)
Sinus tachycardia	29 (19)
Sinus tachycardia and ventricular extrasystole	1 (0.6)
Supraventricular extrasystole	6 (3.8)
Ventricular extrasystole	9 (5.8)
Supraventricular and ventricular extrasystole	1 (0.6)
Atrial fibrillation	3 (1.9)
Regular tachycardia with narrow QRS	7 (4.5)
Sustained monomorphic ventricular tachycardia	1 (0.6)

Values are expressed as No. (%).

with frequent palpitations or recent previous heart disease. However, Dimarco et al.[4] reported a device yield of 76% in patients with low-risk palpitations who had been assessed in cardiology clinics.[5] This percentage is similar to that found in the present study, although our sample included patients with palpitations with a low-risk profile and patients with risk factors. We believe our results to be of relevance, given the scarcity of data on the usefulness of this device to study the etiology of palpitations.

We also draw attention to the high percentage of patients in our study who attended for palpitations and had no arrhythmias coincident with symptoms (54%). In these types of patients, the device can be very useful as a complementary aid to diagnosis. If an arrhythmic origin is ruled out, the patient can be discharged from the cardiology department, thus avoiding repeat consultations.

This monitoring system has been validated against other traditional prolonged ECG monitoring methods and offers several advantages: convenience for patients, simplicity of use, and the ability to monitor the ECG for long periods. It also has disadvantages, such as its inability to detect asymptomatic arrhythmias or arrhythmias of such short duration that they cannot be recorded (eg, isolated and very infrequent extrasystoles).

Our study has the limitations inherent to its retrospective design. In addition, we did not record the time elapsed from the start of monitoring to event onset, and so we could not assess the minimum time needed to achieve the highest yield. Furthermore, the short monitoring period may have led to the low percentage of patients recorded as having no symptoms during the study period. Finally, the short wait between referrals from primary care to our hospital may mean that our results may not be applicable to other primary care centers with longer waits between referrals and visits to cardiology departments. The ECG recordings were interpreted by cardiologists. Thus, the results on diagnostic yield observed in this study cannot be extrapolated to other settings, such as primary care or emergency departments. Studies are needed to validate the diagnostic yield of this monitor when used by other specialists, particularly in primary care settings.

In conclusion, the AliveCor KardiaMobile cardiac monitor is simple to use and can identify the arrhythmic origin of palpitations in a high percentage of patients with palpitations.

FUNDING

AUTHORS' CONTRIBUTIONS

M.E. Salar Alcaraz contributed to data collection, analysis, and interpretation, and to the writing of the manuscript. This author assumes responsibility for all aspects of the article and for investigating and resolving any questions related to the accuracy and veracity of any part of the work. F. Buendía Santiago contributed to data collection and the writing of the manuscript. P.J. Flores Blanco gave final approval to the published version. D.A. Pascual Figal critically revised the manuscript and gave final approval to the published version. A. García Alberola critically revised the manuscript and gave final approval to the published version. S. Manzano Fernández contributed to the conception and design of the study, contributed to data collection, analysis and interpretation, and the writing of the manuscript. This author critically reviewed the manuscript and gave final approval of the published version.

CONFLICTS OF INTEREST

None declared.

María Eladia Salar Alcaraz,[a,][*] Francisco Buendía Santiago,[b] Pedro José Flores Blanco,[c] Arcadio García Alberola,[a,b] Domingo Andrés Pascual Figal,[a,b] and Sergio Manzano Fernández[a,b]

[a]*Servicio de Cardiología, Hospital Clínico Universitario Virgen de la Arrixaca, Instituto Murciano de Investigación Biosanitaria, El Palmar, Murcia, Spain*
[b]*Departamento de Medicina Interna, Facultad de Medicina, Universidad de Murcia, Murcia, Spain*
[c]*Servicio de Cardiología, Hospital Universitario los Arcos del Mar Menor, Instituto Murciano de Investigación Biosanitaria, San Javier, Murcia, Spain*

[*] Corresponding author:
E-mail address: mariela.salar@gmail.com (M.E. Salar Alcaraz).

Available online 6 July 2021

REFERENCES

1. Francisco-Pascual J, Santos-Ortega A, Roca-Luque I, et al. Diagnostic yield and economic assessment of a diagnostic protocol with systematic use of an external loop recorder for patients with palpitations. *Rev Esp Cardiol.* 2019;72:473–478.
2. Selder JL, Breukel L, Blok S, van Rossum AC, Tulevski II, Allaart CP. A mobile one-lead ECG device incorporated in a symptom-driven remote arrhythmia monitoring program. The first 5,982 Hartwacht ECGs. *Neth Heart J.* 2019;27:38–45.
3. Reed MJ, Grubb NR, Lang CC, et al. Multicentre randomised controlled trial of a smartphone-based event recorder alongside standard care versus standard care for patients presenting to the emergency department with palpitations and pre-syn-cope: The IPED (Investigation of Palpitations in the ED) study. *EClinicalMedicine.* 2019;8:37–46.
4. Dimarco AD, Onwordi EN, Murphy CF, et al. Diagnostic utility of real-time smart-phone ECG in the initial investigation of palpitations. *Brit J Cardiol.* 2018. http://doi.org/10.5837/bjc.2018.006
5. López-Cuenca A, Pastor-Pérez FJ, Flores-Blanco PJ, Manzano-Fernández S, Palpita-ciones. En: *Rutas asistenciales consensuadas entre Cardiología y Atención Primaria.* 1.ª ed. Murcia: Servicio Murciano de Salud; 2018:93–97.