CLINICAL RESEARCH
Prevention and epidemiology

Influence of high cardiovascular risk in asymptomatic people on the duration and cost of sick leave: results of the ICARIA study

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Aims	We investigated the potential influence of a moderate-to-high cardiovascular (CV) risk (CVR) (defined as a Systematic COronary Risk Evaluation model, or SCORE $\geq$ 4%), in the absence of an established CV disease, on the duration and cost of CV and non-CV sick leave (SL) resulting from common and occupational accidents or diseases.
Methods and results	We conducted a prospective cohort study on 690 135 workers with a 1-year follow-up and examined CV- and non-CV-related SL episodes. To obtain baseline values, CVR factors were initially assessed at the beginning of the year during routine medical examination. The CVR was calculated with the SCORE charts for all subjects. Moderate-to-high CVR was defined as SCORE $\geq$ 4%. A baseline SCORE $\geq$ 4% was associated with a higher risk for long-term CV and non-CV SL, as revealed by follow-up assessment. This translated into an increased cost, estimated at €5 801 464.18 per year. Furthermore, pharmacological treatment for hypertension or hyperlipidaemia was significantly associated with longer SL duration.
Conclusion	Moderate-to-high CVR in asymptomatic subjects was significantly associated with the duration and cost of CV and non-CV SL. These results constitute the first body of evidence that the SCORE charts can be used to identify people with a non-established CV disease, which might ultimately translate into more lost workdays and therefore increased cost for society.
Keywords	Cardiovascular risk • Sick leave • Sickness absence • Work-related accidents

Introduction

An important component of the economic burden of cardiovascular (CV) disease is the loss of productivity due to CV morbidity and premature death.[1] Several factors are known to delay the return to work following a CV event, increasing the cost of CV-related sick leave (SL). Indeed, many CV risk (CVR) factors (e.g. hypertension,[2] smoking,[3] diabetes,[4] obesity,[5] risk factors collectively known as 'metabolic syndrome',[6] and various health-related risk factors[7]) have been independently and positively associated with SL duration and the costs attributable to CV diseases. These data indicate that CVR factors could have a significant, deleterious economic impact even before overt CV disease is apparent.[8] Therefore, the control of CVR factors through lifestyle modification and/or pharmacological intervention might not only help save lives, but may also reduce the direct and indirect costs incurred as a result of lost productivity.[9–11]

More than 5 million SL episodes are recorded annually in Spain, and the cost of providing temporary sick pay benefits exceeds €6000 million annually.[12] Thus, SL analysis is valuable not only for estimating imputable costs, but also for identifying groups with increased health

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risks that are in need of targeted intervention.[13] Routine medical examination provides an opportunity for early screening of workers for vascular risk factors and to select subjects with high CVR for more intensive intervention.[14,15]

In this context, we investigated the relationship between global CVR and the incidence, length, and cost of CV-disease-related SL. In addition, we examined the role of CVR in SL resulting from non-CV diseases and work-related accidents, which, to our knowledge, has never been investigated.

The aim of this study was therefore to investigate the relationship between global CVR, which was estimated using SCORE charts,[16] and the 1-year incidence, length and cost of SL for CV-, non-CV-, or work accident-related reasons. Specifically, we analysed a large, representative sample of the Spanish workforce to gain a better understanding of the financial burdens associated with CVR in this group.

Methods

Study design and participants

This prospective cohort analysis was part of the ICARIA (Ibermutuamur CArdiovascular RIsk Assessment) study.[15] Ibermutuamur is a mutual insurance company for work-related accidents and occupational illnesses that covers a population of approximately 1 million workers. Mutual insurance companies in Spain collaborate with National Social Security to administer statutory sick pay. Their responsibility also includes providing health care in the event of work-related accidents or occupational illnesses. In addition, a subsidiary company of Ibermutuamur (Sociedad de Prevención de Ibermutuamur) focuses specifically on preventing diseases and accidents by monitoring and promoting the health of workers through routine annual medical examination, among other things.

A total of 1 441 267 medical examinations were performed between May 2004 and December 2007. However, only data from each subject's first examination, containing all relevant CVR information, were considered in the present study. A total of 690 135 subjects were included in this study (71.6% male; mean ages: 36 for males and 34 for females; age range: 16−75). No significant socio-demographic differences (i.e. age, gender, occupational sector, and geographical distribution) were detected between workers who were included in the study and those who were not (data not shown). Importantly, this population was representative of the Spanish workforce.[15] Records of physician-certified SL episodes over a 1-year period were obtained from the Social Security Register for SL due to common diseases and the Ibermutuamur Register for SL due to work-related accidents. For SL episodes due to CV disease, the ICD-9[17] codes 401−414 and 426−443 were considered, with the exception of codes 426.7, 429.0, 430.0, 432.1, 437.3, 437.4, and 437.5, which relate to non-atherosclerotic causes of death. This corresponds to endpoints defined in the SCORE project.[16]

The SCORE chart is the most widely used European CVR assessment tool and can be used to determine whether a subject is at high CVR (10-year risk of CV death is ≥5%), moderate CVR (10-year risk of 4−4.9%), or low CVR (10-year risk of <4%).[16,18] Additional information regarding risk factor measurement and CVR classification in the ICARIA study has been provided previously.[15,18] Here, CV disease was defined as a clinically documented diagnosis of coronary, cerebrovascular, or peripheral arterial disease. Workers with type 1 or type 2 diabetes were excluded from this study.

The subjects were divided into two age groups (<45 vs. ≥45, the latter representing approximately the upper 20th age percentile), and two occupational groups based on the Spanish National Classification of Occupations [blue-collar (BC) workers and white-collar (WC) workers].[18] They were also classified according to smoking status (smoker vs. non-smoker).[15]

Sick leave parameters

All 690 135 workers were monitored for 1 year after the date of their first medical examination. Incidence, duration (days), and contribution basis (in euro) were obtained for SL episodes caused by common CV-, non-CV-, or work accident-related reasons. The total number of SL days taken by each worker was then totalled and used as a dependent variable in analyses focused on SL duration.

Ethical issues

Signed informed consent was obtained from all participants before enrolment in the study, in accordance with the principles stated in the Declaration of Helsinki. The protocol was reviewed and approved by the local Ethics Committee.

Statistical analysis

All the statistical analyses were performed at the patient level. The annual incidence of at least one SL episode caused by common non-CV diseases, CV diseases, or work-related accidents was calculated separately in the overall cohort, and according to each variable considered (gender, age, occupation, smoking status, and CVR profile). Data were presented as percentages with 95% confidence intervals. A χ^2 test was used to compare the SL incidence between the groups. The median and respective 25th and 75th percentiles were calculated for SL duration. The differences in median duration between groups were evaluated with the two-sample median test. Poisson regression was utilized for analysis of the association between CVR and SL duration. Crude and adjusted rate ratios (RRs) were calculated, adjusted by age, smoking status, or combined variables (gender, age, occupation, and smoking status). In addition, an over-dispersion correction for standard errors was performed. Furthermore, data were calculated separately for CV diseases, non-CV diseases, and work-related accidents. Categories with a lower median duration for all variables were used as the reference. Finally, the economic impact of longer SL durations in moderate-to-high CVR workers was estimated by multiplying the mean contribution basis of employees by the estimated increase in SL days in subjects with moderate-to-high CVR, and then by the number of workers in each SL group. Adjusted RRs were used to estimate the increase in SL days in moderate-to-high CVR with respect to the low CVR group, when such an association remained significant after entering covariates in the Poisson regression models. All analyses were performed using the SAS statistical package (SAS v. 9.1, SAS Institute, Inc., Cary, NC, USA).

Results

Sick leave due to common non-cardiovascular diseases

The incidence of SL caused by common non-CV diseases was 13.9%, and the median duration of SL was 11 days (*Table 1*, Non-CV diseases). Both incidence and duration were higher in women than in men, in smokers than in non-smokers, and in BC than in WC workers. Age ≥45 years was associated with a lower incidence but longer duration of SL. Workers with moderate-to-high CVR had an SL incidence that was not significantly different from low CVR individuals, but SL duration for moderate/high individuals was about twice as long (median duration 18 vs. 11 days, $P < 0.0001$).

Table I One-year incidence of at least one sick leave episode caused by common non-cardiovascular diseases, work-related accidents, cardiovascular diseases, and sick leave duration (days) in a cohort of 690 135 workers (overall study population and data segmented by gender, age, smoking status, occupation, and cardiovascular risk profile)

Demographic, health, and occupational variables	Number of workers with at least one sick leave episode	Incidence[a] (95% CI)	P-value[b]	Median total duration (P25;P75)	P-value[c]
Non-cardiovascular diseases					
Gender					
Male	64 871	13.1 (12.1−14.05)	<0.0001	11 (5;28)	<0.0001
Female	31 376	16.1 (14.4−17.7)		13 (5;39)	
Age (years)					
<45	80 303	14.4 (13.5−15.3)	<0.0001	10 (5;28)	<0.0001
≥45	15 944	11.9 (10.2−13.6)		18 (7;58)	
Smoking status					
Smoker	51 465	15.5 (15.3−15.6)	<0.0001	11 (5;31)	0.0014
Non-smoker	44 782	12.5 (12.4−12.6)		11 (5;33)	
Occupation					
Blue collar	66 992	14.8 (13.7−15.8)	<0.0001	11 (5;32)	0.2636
White collar	29 255	12.2 (10.9−13.5)		11 (5;32)	
Cardiovascular risk profile					
Moderate to high	5391	12.8 (9.6−15.9)	0.42	18 (8;57)	<0.0001
Low	90 856	14.0 (13.1−14.8)		11 (5;31)	
Total	96 247	13.9 (13.1−14.7)		11 (5;32)	
Work-related accidents					
Gender					
Male	40 589	8.2 (7.4−8.9)	<0.0001	11 (6;25)	<0.0001
Female	6187	3.1 (2.3−3.9)		13 (7;28)	
Age (years)					
<45	38 634	6.9 (6.2−7.6)	0.04	11 (6;23)	<0.0001
≥45	8142	6.1 (4.8−7.3)		14 (7;36)	
Smoking status					
Smoker	27 912	8.38 (8.3−8.5)	<0.0001	11 (6;24)	<0.0001
Non-smoker	18 864	5.28 (5.2−5.4)		11 (6;27)	
Occupation					
Blue collar	42 541	9.4 (8.5−10.2)	<0.0001	11 (6;25)	<0.0001
White collar	4235	1.7 (1.2−2.3)		13 (6;29)	
Cardiovascular risk profile					
Moderate to high	2940	6.9 (4.5−9.4)	0.46	13 (7;34)	<0.0001
Low	43 836	6.7 (6.1−7.3)		11 (6;25)	
Total	46 776	6.7 (6.1−7.3)		11 (6;25)	
Cardiovascular diseases					
Gender					
Male	604	0.12 (0.10−0.14)	<0.0001	101.5 (31.5;235)	0.0011
Female	77	0.04 (0.03−0.05)		29 (12;153)	
Age (years)					
<45	252	0.05 (0.03−0.07)	<0.0001	54 (13;149.5)	<0.0001
≥45	429	0.32 (0.28−0.367)		122 (39;253)	
Smoking status					
Smoker	380	0.11 (0.09−0.13)	<0.0001	108.50 (33;249.50)	0.0403
Non-smoker	301	0.08 (0.06−0.10)		74 (19;191)	
Occupation					
Blue collar	502	0.11 (0.09−0.13)	<0.0001	96 (26;250)	0.3496
White collar	179	0.08 (0.06−0.10)		88 (25;174)	

Continued

Table 1 *Continued*

Demographic, health, and occupational variables	Number of workers with at least one sick leave episode	Incidence[a] (95% CI)	P-value[b]	Median total duration (P25;P75)	P-value[c]
Cardiovascular risk profile					
Moderate to high	278	0.66 (0.62−0.70)	<0.0001	111 (36;250)	0.0218
Low	403	0.06 (0.04−0.08)		79 (19;201)	
Total	681	0.10 (0.09−0.11)		92 (26;225)	

95% CI, 95% confidence interval; P25;P75, 25th and 75th percentiles.
[a]Percentage of individuals with at least one sick leave episode.
[b]P-value for χ^2 test.
[c]P-value for two-sample median test.

Non-CV diseases causing SL episodes were mainly: (i) diseases of the respiratory system (ICD 460−519); (ii) diseases of the musculo-skeletal system and connective tissue (ICD 710−739); (iii) injury and poisoning (ICD 800−999); (iv) poorly defined conditions (ICD 780−799); (v) infectious or parasitic diseases (ICD 001−139); (vi) diseases of the digestive system (ICD 520−579); (vii) mental disorders (ICD 290−319); (viii) and diseases of the nervous system and sense organs (ICD 320−389). In each of these conditions, the median SL duration was significantly longer in individuals with moderate-to-high CVR than with low CVR.

Sick leave due to work-related accidents

The overall incidence of SL caused by work-related accidents (6.8%) was significantly lower than that caused by common non-CV diseases, but the median duration (11 days) was similar (*Table 1*, Work-related accidents). The duration was slightly longer in women and individuals ≥45 years, but not in smokers. On the other hand, BC workers had a slightly shorter median duration of SL. Moreover, moderate-to-high CVR was significantly associated with a longer median duration of SL due to work-related accidents.

Sick leave due to common cardiovascular diseases

As expected for the relatively young population of workers included in the ICARIA study, the incidence of SL caused by common CV diseases was very low (0.10%), i.e. much lower than the incidence of SL due to non-CV diseases or to work-related accidents (*Table 1*, CV diseases). The occurrence of CV-related SL was significantly higher in men, individuals ≥45 years, smokers, and BC workers. Moreover, the risk of SL due to CV disease for moderate-to-high CVR individuals, although rather low (0.66%), was >10 times higher than for low CVR individuals (0.06%, *P* < 0.0001). On the other hand, the median duration of CV-related SL was notably long (92 days), and significantly longer in men, older workers, and smokers. The median SL duration was also significantly greater for individuals at moderate/high CVR than for individuals at low CVR.

Association with cardiovascular treatment

As shown in *Table 2*, 26% of workers with moderate-to-high CVR and 3% of those with low CVR were being treated for arterial hypertension and/or hyperlipidaemia. The median duration of SL caused by common

non-CV diseases or work-related accidents for these treated patients (both higher and lower CVR) was significantly longer than that of subjects without pharmacological treatment (*P* < 0.0001 in all cases). A similar trend was observed for CV-related SL, but the difference did not reach statistical significance, likely because of the small sample size. Finally, pharmacologically treated patients were older than untreated ones, with the age difference small in the moderate-to-high CVR group (54.5 ± 7.5 vs. 50.1 ± 10.3; *P* < 0.0001) and more pronounced in the low CVR group (47.7 ± 8.7 vs. 34.1 ± 9.7; *P* < 0.0001).

Role of associated variables

The results of the Poisson regression analyses for the association of CVR with SL duration following covariate adjustment are presented in *Table 3*. Moderate-to-high CVR was associated with a significant increase in SL duration for CV or non-CV causes. Although the inclusion of age in the model reduced the magnitude of the estimated association between CVR and SL duration, the association remained significant for all three SL categories. Results from models that also adjusted for sex, occupation, and smoking status continued to reveal a significant association between CVR and SL duration for SL due to non-CV diseases and CV diseases, but no significant association for work-related accidents.

Cost analysis

Estimates of the additional costs associated with increased SL taken by individuals at higher CVR are summarized in *Table 4*. We estimated that the lengthened duration of non-CV-disease-related SL in individuals with moderate-to-high CVR amounted to additional costs of €2 151 920.99, and that €3 649 543.19 would be due to overt CV diseases, with a total additional cost of €5 801 464.18 during only the first year following initial medical examination.

Discussion

The most important and novel finding of this study is that moderate-to-high CVR was associated with an increased duration and cost of SL caused by common non-CV diseases.

A separate analysis of single CVR factors or patient characteristics demonstrated that many factors contributed to the increased duration of non-CV disease SL, confirming previously reported data.[2−8] However, in our study, even though gender, age, occupation, and

Table 2 Number of workers with at least one sick leave episode caused by a common disease or work-related accident for non-cardiovascular reasons or due to cardiovascular diseases and sick leave duration in workers with moderate-to-high and low cardiovascular risk, with or without treatment for hypertension and/or hyperlipidaemia, in a cohort of 690 135 workers with a 1-year follow-up

Cardiovascular risk	With or without treatment	Number of workers with at least one sick leave episode	Median total duration	P25;P75	P-value[b]
Common disease					
Moderate to high	With treatment	1393	20	8;64	<0.0001
	Without treatment	3998	18	7;53	
Low	With treatment	2805	17	7;52	<0.0001
	Without treatment	88 051	11	5;30	
Work-related accident					
Moderate to high	With treatment	652	16	7;39.5	<0.0001
	Without treatment	2288	13	7;33	
Low	With treatment	1307	13	6;32	<0.0001
	Without treatment	42 529	11	6;24	
Cardiovascular diseases					
Moderate to high	With treatment	125	106	36;257	0.7121
	Without treatment	139	115	36;250	
Low	With treatment	68	102	30;239.5	0.2844
	Without treatment	308	73	18.5;184.5	

P25;P75, 25th and 75th percentiles.
[a]P-value for two-sample median test.

Table 3 Crude and adjusted association between cardiovascular risk and sick leave duration caused by a common disease or work-related accident for non-cardiovascular reasons or due to cardiovascular diseases, calculated with a Poisson regression model (Poisson regression, stepwise adjusted model)

Cardiovascular risk	Model I: crude			Model II: adjusted by age			Model III: adjusted by sex, age, occupation, and smoking status		
	RR	95% CI	P-value	RR	95% CI	P-value	RR	95% CI	P-value
Common disease									
Moderate to high	1.58	1.51–1.67	<0.0001	1.21	1.15–1.28	<0.0001	1.23	1.17–1.30	<0.0001
Low	1			1			1		
Work-related accident									
Moderate to high	1.43	1.32–1.54	<0.0001	1.23	1.14–1.34	<0.0001	0.97	0.90–1.04	0.3855
Low	1			1			1		
Cardiovascular diseases									
Moderate to high	12.68	10.18–15.80	<0.0001	3.74	2.92–4.81	<0.0001	2.80	2.14–3.67	<0.0001
Low	1			1			1		

RR, rate ratio; 95% CI, 95% confidence interval.
Poisson regression model; RR < 1 indicates a shorter sick leave duration; RR > 1 indicates a longer sick leave duration.

smoking status were separately associated with SL incidence and duration, they did not completely account for the increased length of non-CV-related SL when global CVR was elevated. Thus, our results indicate that the SCORE charts identify workers with non-established CV disease that might contribute to increased lost work-days, and therefore higher cost for society. On the other hand, increased duration of SL due to work accidents in subjects with moderate-to-high CVR disappeared after adjusting for covariates.

To our knowledge, this prospective cohort study is the first to estimate the difference in costs associated with SL in workers with a moderate-to-high global CVR compared with those with a low CVR. Altogether, our study revealed an approximate increase in SL-associated cost (due primarily to SL caused by CV and non-CV common diseases in males) of €5 801 464.18 in the year after initial medical examination. When extrapolated to the total active Spanish workforce, this cost can be estimated at about €145

Table 4 Adjusted estimation of 1-year costs associated with increased risk of sick leave among workers with moderate-to-high and low cardiovascular risk in a cohort of 690 135 workers

Cardiovascular risk profile	n		Mean sick leave duration	RR	Contribution basis		Additional sickness absence days			Final cost		Total cost
	Male	Female			Male	Female	Male	Female	Total	Male	Female	
Common disease												
Moderate to high	4852	539	62.4	0.23	49.34	40.72	39 951.37	4438.13	44 389.49	1 971 200.50	180 720.49	2 151 920.99
Low	60 019	30 837	35.8	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Cardiovascular diseases												
Moderate to high	262	16	170.72	1.8	51.29	43.81	67 627.44	4129.92	71 757.36	3 468 611.4	180 931.80	3 649 543.19
Low	342	61	143.4	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Total									116 146.85			5 801 464.18

million per year. Moreover, our data estimated an increased cost associated with the early stages of CV disease in people with a SCORE $\geq 4\%$, and indicated that these costs are partly unrelated to SL for CV disease. In addition to CV diseases, these heightened costs could result from increased SL caused by other types of non-CV diseases (e.g. respiratory, gastrointestinal, musculoskeletal, or infectious).

The reasons for this association between increased global CVR and longer duration of non-CV-related SL are unclear. The subjects included in the ICARIA study were relatively young (mean age of 36 years), and only 20% of them were ≥ 45 years old. In addition, even those with a higher CVR level were unlikely to develop a consistent number of CV complications within the first year following initial examination, and this could explain the paucity of SL episodes attributed to CV diseases in the ICARIA cohort. Furthermore, some CVR factors, such as age and smoking, are also linked to a number of non-CV diseases. However, although these risk factors (especially age) appeared to play some role, adjusting for these and other CVR factors could not entirely account for the association between global CVR and non-CV disease SL duration. We can propose two distinct hypotheses that could explain this association. First, increased CVR may signify a broader general risk for common diseases, including non-CV-related illnesses, since higher CVR can indicate frailer individuals. This may be due to the fact that CVR is often associated with pro-inflammatory or pro-thrombotic states,[19,20] which are also known to contribute to a number of non-CV diseases (e.g. respiratory diseases, musculoskeletal pathology, or infectious diseases). Thus, it is important to note that both CV diseases and a wide range of common non-CV diseases are rooted in the same clusters of health risk behaviours, which have become prominent in the Western world. Moreover, voluntary risk exposure, such as smoking, could be indicative of a risky personality type, and individuals who would regularly engage in such unsafe conduct may be more likely to be exposed to additional lifestyle-related hazards (e.g. risky sports, unsafe driving habits, and/or multiple sexual partners).[21]

A second hypothesis that could account for the association between CVR and non-CV-related SL duration involves a patient's growing awareness of their CVR. It is possible that becoming labelled as high risk for CV disease ultimately leads to a protective response in some individuals, who increase their number of SL episodes or elect longer SL durations. In this regard, we would like to point out that patients who were noted as having low or moderate/high CVR, and who were prescribed CV drug treatment (BP lowering or lipid lowering), had significantly longer SL due to non-CV diseases or work-related accidents. However, this observation is not entirely unexpected, as it is well known from prospective observational studies that hypertensive patients receiving treatment have a higher outcome incidence than untreated hypertensive patients,[22–24] even though this directly contradicts data from controlled, randomized trials that consistently show outcome reduction by antihypertensive therapy.[25] These discrepancies are thought to result from the fact that, in clinical practice, hypertensive patients are prescribed drug treatment when their global risk is elevated, whereas lower global risk hypertensive patients are often left untreated. This habit is consistent with the existing guidelines,[26] and with the reimbursement policies of some national health services, which only reimburse antihypertensive drugs or statins to patients with a high global CVR.

Indeed, in the ICARIA study, workers under CV treatment were older than untreated workers. However, among moderate-to-high CVR individuals, age difference was rather small (54 vs. 50 years), and is unlikely to be the main factor causing the difference in SL duration. It is, therefore, plausible that, in the ICARIA study, workers receiving CV drugs were in the upper part of the CVR range in which they had been classified, which obscured beneficial treatment effects and justified longer SL periods. Furthermore, regarding CVR awareness, receiving a drug prescription for CV reasons is likely to elicit a greater worry response from patients. Finally, but less probable, adverse effects due to drug treatment may lengthen SL duration.

In conclusion, our study shows that a higher level of CVR increases the duration of SL, due not only to CV diseases, but also to common non-CV diseases. Thus, CVR contributes to a marked increase in the financial burden resulting from SL, which we have calculated as €5 801 464.18 in 1 year for the 690 135 workers included in our study. The obvious conclusion is that workplace preventive measures aimed at early control of CVR[27] may be widely beneficial in terms of health since they likely influence non-CV diseases as well. Ultimately, this could decrease the financial burden on society by reducing SL duration. Moreover, the notion that labelling a patient as higher CVR may cause concern, which consequently lengthens rather than reduces SL duration, should not deter prevention. Instead, this idea should promote the continued development of patient and employee education initiatives to communicate health information more precisely to workers. However, because our study was only observational, these inferences should be appropriately tested in an interventional study.

Advantages and limitations

The key advantages of this study were the prospective design, the sample size (approximately 700 000 workers of both genders in all occupational sectors), and the analysis of various types of SL, namely those caused by non-CV diseases, CV diseases, and work-related accidents.

Regarding study limitations, although the ICARIA cohort could be representative of the Spanish workforce,[15] the generalizability of our results should be tested in other countries. Additionally, the SCORE charts present some limitations, such as overestimation of CVR in individuals ≥ 65 years of age, underestimation of CVR in younger individuals, and exclusion of variables (e.g. family history of early onset coronary heart disease, impaired glucose tolerance, and hypertriglyceridaemia). Nevertheless, the SCORE charts are widely used to calculate CVR, and have been validated and calibrated in Spain.[28]

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CARDIOVASCULAR FLASHLIGHT

Assessment of the vortex flow in the post-stenotic dilatation above the pulmonary valve stenosis in an infant using echocardiography vector flow mapping

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A 15-month-old male diagnosed with double outlet right ventricle (DORV) suffered from right ventricular failure 8 months after DORV repair. The motion of the anterior cusp of the pulmonary valve (PV) after the commissurotomy of the bucuspid valve was poor on echocardiography, and computed tomography showed post-stenotic dilatation (*Panels A* and *B*). We assessed the blood flow in the post-stenotic dilatation site of the main pulmonary artery (mPA) using echocardiography vector flow mapping (VFM). VFM is a new technology that makes it possible to visualize the flow velocity vector, and to calculate energy loss (EL) which results from the viscous dissipation in turbulent blood flow using colour Doppler mapping and speckle tracking and is thought to be the ventricular workload. The flow velocity vector analysis clearly showed that a large vortex formed from the posterior wall to the anterior wall just above the PV, and high EL was detected even though no pressure drop was detected by catheterization (*Panels C* and *D*). After PV plasty with commissurotomy, the vortex diminished, resulting in a decrease of the mPA diameter. Additionally, the EL level at the mPA during the systolic phase considerably decreased after the procedure (*Panels E–G*). In the present case, the flow vector analysis visualized the abnormalities of blood flow above the PV stenosis. In addition, although further accumulation of such cases is warranted, EL would be a novel parameter that can be used to quantitatively evaluate the pressure overload for the ventricles caused by stenotic lesions.
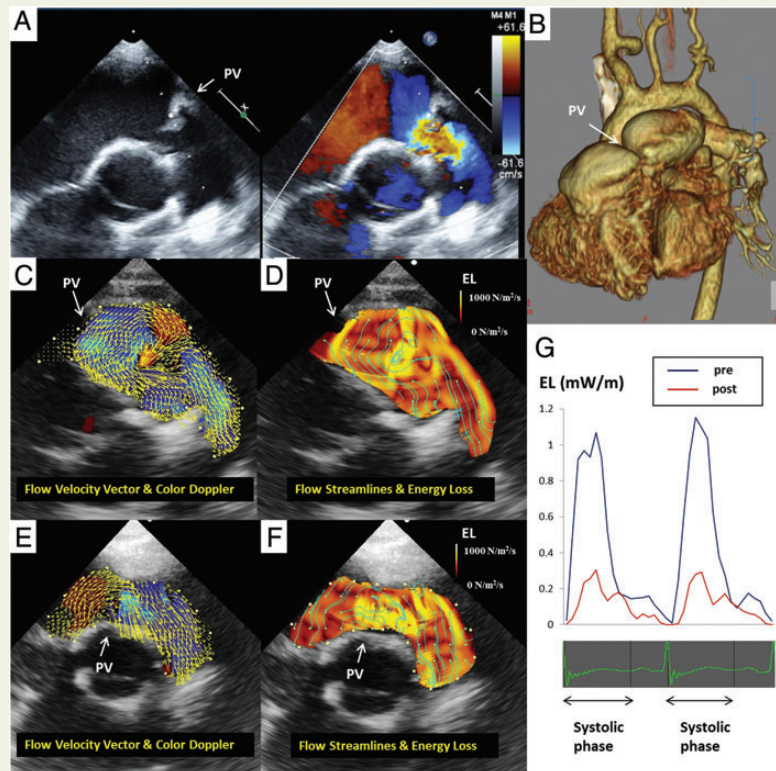
Each author contributed to the care of the patient as well as the composition and review of the paper.

Supplementary material is available at *European Heart Journal* online.