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ORIGINAL ARTICLE

Current national availability of advanced echocardiography imaging: real world data from an Italian Society of Echocardiography and Cardiovascular Imaging survey

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Abstract

Aims

Advanced echocardiographic imaging (AEI) techniques, such as three-dimensional (3D) and multi-chamber speckle-tracking deformation imaging (strain) analysis, have been shown to be more accurate in assessing heart chamber geometry and function when compared with conventional echocardiography providing additional prognostic value. However, incorporating AEI alongside standard examinations may be heterogeneous between echo laboratories (echo labs). Thus, our goal was to gain a better understanding of the many AEI modalities that are available and employed in Italy.

Methods and results

The Italian Society of Echocardiography and Cardiovascular Imaging (SIECVI) conducted a national survey over a month (November 2022) to describe the use of AEI in Italy. Data were retrieved via an electronic survey based on a structured questionnaire uploaded on the SIECVI website. Data obtained from 173 echo labs were divided into 3 groups, according to the numbers of echocardiograms performed: <250 exams (low-volume activity, 53 centres), between 251 and 550 exams (moderate-volume activity, 62 centres), and ≥550 exams (high-volume activity, 58 centres). Transthoracic echocardiography (TTE) 3D was in use in 75% of centres with a consistent difference between low (55%), medium (71%), and high

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activity volume (85%) ($P = 0.002$), while 3D transoesophageal echocardiography (TEE) was in use in 84% of centres, reaching the 95% in high activity volume echo labs ($P = 0.006$). In centres with available 3D TTE, it was used for the left ventricle (LV) analysis in 67%, for the right ventricle (RV) in 45%, and for the left atrium (LA) in 40%, showing greater use in high-volume centres compared with low- and medium-volume centres (all $P < 0.04$). Strain analysis was utilized in most echo labs (80%), with a trend towards greater use in high-volume centres than low- and medium-volume centres (77%, 74%, and 90%, respectively; $P = 0.08$). In centres with available strain analysis, it was mainly employed for the LV (80%) and much less frequently for the RV and LA (49% and 48%, respectively).

Conclusion In Italy, the AEI modalities are more frequently available in centres with high-volume activity but employed only in a few applications, being more frequent in analysing the LV compared with the RV and LA. Therefore, the echocardiography community and SIECVI should promote uniformity and effective training across the Italian centres. Meanwhile, collaborations across centres with various resources and expertise should be encouraged to use the benefits of the AEI.

Keywords national survey • advanced echocardiography imaging • technologies

Introduction

Advanced echocardiographic imaging (AEI) techniques, such as three-dimensional (3D) and multi-chamber speckle-tracking deformation imaging (strain) analysis, have been shown to be more accurate in assessing heart chamber geometry and function, as well as providing additional prognostic value, when compared with conventional two-dimensional echocardiography.[1–3] Also, new automated on-cart equipment has recently been proven to perform precise, quick, and repeatable strain and 3D evaluations of the heart chambers.[4–6] Therefore, AEI is frequently highlighted by the current recommendation documents from the European Association of Cardiovascular Imaging (EACVI) and the American Society of Echocardiography (ASE) as a state-of-the-art approach for patient evaluation.[7–10] However, each echocardiographic laboratory's (echo labs) capacity to incorporate AEI alongside standard examinations may differ based on internal structure, workload, financial resources, experience, and patient population. Accordingly, this survey aims to obtain more knowledge about the AEI methods used in Italy to influence future strategies for optimizing their integration and widespread clinical deployment into regular patient evaluation.

Methods

Our recent publication described the national survey methodology in detail.[11] Compared with the initial database, we analysed only the echo labs within cardiology units and departments over 1 month of activity. November 2022 was chosen as an ideal reference month (regular planning of activities in the absence of national holidays). A list of SIECVI-accredited echo labs was reviewed to contact each member by e-mail. Data from members were retrieved via an electronic survey based on a structured questionnaire uploaded on the SIECVI website (www.siec.it.). For allocation of the response, the questionnaire required general information, such as the name of the hospital, the investigator, and the interviewed person's name: (i) general information: date, hospital's name, department, name of the interviewed physician, city, and region of Italy; (ii) the number of exams performed, divided by type; and (iii) the number of echocardiographic machines/transducers/software according to AEI analysis divided for cardiac chambers.

Statistical analysis

Categorical data are expressed in terms of the number of subjects and percentage, while continuous data are expressed as mean ± standard deviation or median (minimum–maximum) depending on the variables' distribution. For continuous variables, inter-group differences were tested with a one-way analysis of variance and inter-group comparison by Bonferroni or Kruskal–Wallis, followed by the Mann–Whitney test as appropriate. The χ^2 test or Fisher exact test was used to compare the distribution of categorical variables among groups. Statistical analysis was performed using the JMP PRO software package, version 16 (SAS Institute Inc., Cary, NC).

Results

Data were obtained from 173 cardiology units and department echo labs (*Table 1*). The median of echocardiographic exams was 400 (IQ range 250–650). Echo labs were divided into 3 groups according to the volume of activity: <250 exams/month (low-volume, 53 centres, 31%, mean 172 ± 72), 251–550 exams/month (medium-volume, 62 centres, 36%, mean 391 ± 76), and ≥550 exams/months (high-volume, 58 centres, 33%, mean 1001 ± 537). Participant echo labs composed an adequate coverage of the national territory but with a higher distribution in the north (88 centres, 51%) compared with the centre (32, 18%) and south (53, 31%) of Italy (*Figure 1*). The volume of activity was also more pronounced in the north (high volume 62%) compared with the centre (17%) and south of Italy (21%), $P = 0.005$. The mean number of transoesophageal echocardiogram (TEE) was 30 ± 25, rising proportionally to the activity of the centres (low-volume 15 ± 15, medium-volume 25 ± 23, high-volume 48 ± 33), $P < 0.0001$.

The facility to perform any 3D evaluation shows a good distribution on a national level (mean number of 3D machines and/or transducers 2.1 ± 1.5), with increasing accessibility according to the volume of activity (low 1.5 ± 1.1, medium 1.8 ± 1.3, high 2.9 ± 2.0, $P < 0.0001$). Specifically, transthoracic echocardiography (TTE) 3D was in use in 75% of centres with a consistent difference between low (55%), medium (71%), and high volume (85%), $P = 0.002$, while TEE 3D was in use in 84% of centres, reaching the 95% in high-volume echo labs ($P = 0.006$) (*Figure 2*).

In centres with available TTE 3D, it was used for the left ventricle (LV) in 67%, for the right ventricle (RV) in 45%, and for the left atrium (LA) in 40%, showing greater use in high-volume centres compared with low- and medium-volume centres (all $P < 0.04$).

Strain analysis was utilized in most echo labs (80%), with a trend towards greater use in high-volume centres than low- and medium-volume centres (77%, 74%, and 90%, respectively), $P = 0.08$ (*Figure 2*). In centres with available strain analysis, it was mainly employed for the LV (80%) and much less frequently for the RV and LA (49% and 48%, respectively).

Discussion

The present survey provides unique real-world data about AEI distribution at a national level. The main findings were as follows: (i) currently,

Table 1 General and technological results in the Italian echo lab overall and according to volume of activity

	Overall ($n = 173$)	Low- volume <250 ex/months ($n = 53$, 31%)	Moderate-volume ex/month 250–550 ($n = 62$, 36%)	High-volume ex/month >550 ($n = 58$, 33%)	*P*-value
North Italy	88 (51%)	16 (30%)	36 (58%)	36 (62%)	0.005
Centre Italy	32 (18%)	12 (23%)	10 (16%)	10 (17%)	
South Italy	53 (31%)	25 (47%)	16 (26%)	12 (21%)	
Echocardiography machines, *n*	5.0 ± 3.0	3.5 ± 1.8	4.0 ± 1.8	7.5 ± 4.5	<0.001
Multivendor	114 (66%)	33 (62%)	35 (56%)	46 (79%)	0.02
3D echocardiography machines/transducer	2.1 ± 1.5	1.5 ± 1.1	1.8 ± 1.3	2.9 ± 2.0	<0.0001
Use of 3D transthoracic	122 (75%)	29 (55%)	44 (71%)	49 (85%)	0.002
Use of 3D transoesophageal	146 (84%)	38 (72%)	54 (87%)	54 (95%)	0.006
Global longitudinal strain, yes	139 (80%)	41 (77%)	46 (74%)	52 (90%)	0.08
LV GLS					
No	34 (20%)	12 (23%)	16 (26%)	6 (10%)	0.04
1–20%	27 (16%)	8 (15%)	13 (21%)	6 (10%)	
21–49%	35 (20%)	13 (25%)	8 (13%)	14 (24%)	
50–99%	48 (28%)	9 (17%)	15 (24%)	24 (41%)	
100%	29 (17%)	11 (21%)	10 (16%)	8 (14%)	
RV GLS					
No	89 (51%)	34 (64%)	39 (63%)	16 (28%)	0.001
1–20%	47 (27%)	10 (19%)	12 (19%)	25 (43%)	
21–49%	23 (13%)	7 (13%)	6 (10%)	10 (17%)	
50–99%	13 (8%)	1 (2%)	5 (8%)	7 (12%)	
100%	1 (1%)	1 (2%)	0	0	
LA GLS					
No	90 (52%)	36 (68%)	36 (58%)	18 (31%)	0.001
1–20%	50 (29%)	11 (20%)	13 (21%)	26 (45%)	
21–49%	22 (13%)	5 (9%)	10 (16%)	7 (12%)	
50–99%	10 (6%)	0	3 (5%)	7 (12%)	
100%	1 (1%)	1 (2%)	0	0	
3D transthoracic, yes	122 (71%)	29 (55%)	44 (71%)	49 (84%)	0.002
LV 3D					
No	57 (33%)	25 (47%)	23 (37%)	9 (16%)	0.04
1–20%	44 (26%)	12 (23%)	16 (26%)	16 (28%)	
21–49%	30 (17%)	5 (9%)	9 (15%)	16 (28%)	
50–99%	30 (17%)	8 (15%)	10 (16%)	12 (21%)	
100%	11 (7%)	3 (6%)	4 (6%)	4 (7%)	
RV 3D					
No	94 (55%)	40 (75%)	37 (60%)	17 (30%)	0.0008
1–20%	41 (24%)	6 (11%)	13 (21%)	22 (39%)	
21–49%	21 (12%)	2 (4%)	8 (13%)	11 (19%)	
50–99%	13 (8%)	4 (8%)	3 (5%)	6 (11%)	
100%	3 (2%)	1 (2%)	1 (2%)	1 (2%)	
LA 3D					
No	102 (60%)	41 (77%)	35 (57%)	26 (45%)	0.04
1–20%	45 (26%)	5 (9%)	18 (30%)	22 (39%)	
21–49%	17 (10%)	4 (8%)	7 (12%)	6 (11%)	
50–99%	5 (3%)	2 (4%)	1 (2%)	2 (4%)	
100%	2 (1%)	1 (2%)	0	1 (2%)	
TEE 3D					
No	27 (16%)	15 (28%)	8 (13%)	4 (7%)	0.008
21–49%	25 (14%)	4 (8%)	11 (18%)	10 (17%)	
50–99%	61 (35%)	20 (38%)	25 (40%)	16 (28%)	
100%	60 (35%)	14 (26%)	18 (29%)	28 (48%)	

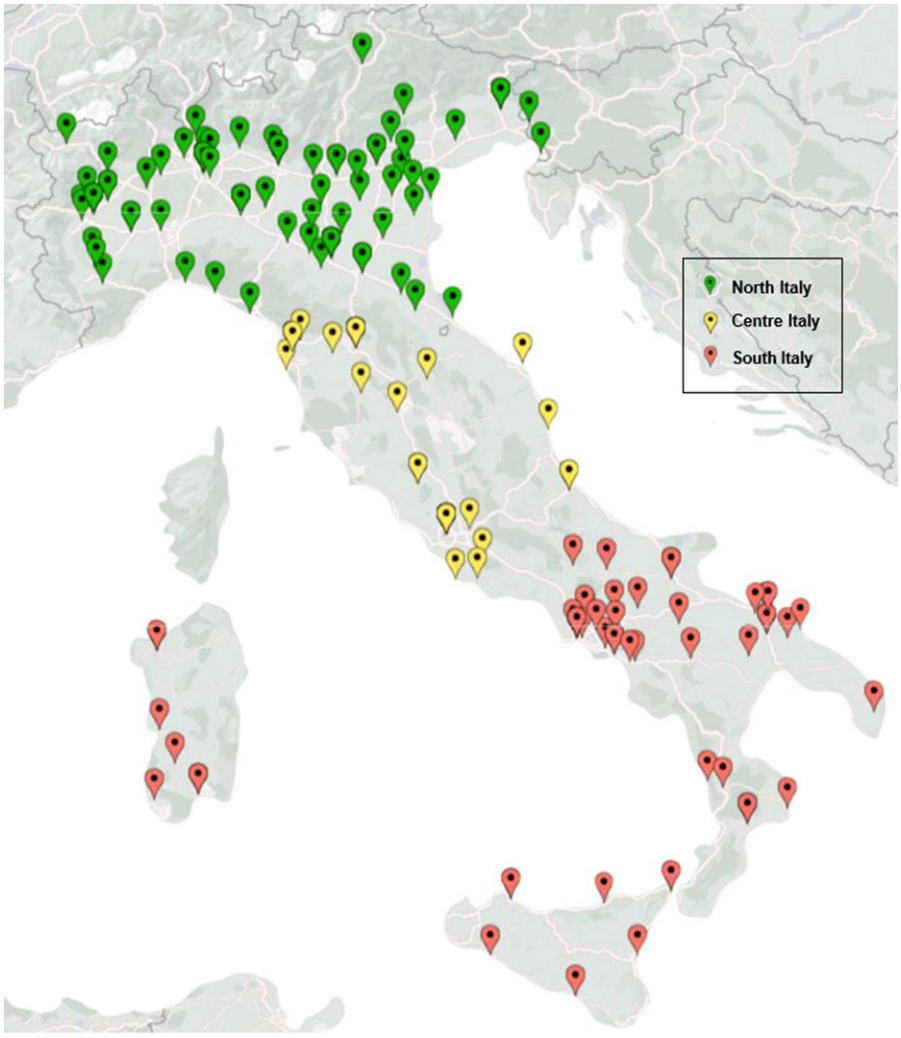

Figure 1 Geographical distribution of the participating centres.

AEI is not part of the routine examination in most laboratories, especially in those with low- and medium-volume activity; (ii) nearly three-quarters of the centres have 3D TTE available for the assessment of LV, but less than half for the assessment of RV and LA; (iii) the vast majority of centres has the chance of performing a 3D TEE, which almost universal in centres with a high volume of activity; and (iv) although the strain technology is available in most echo labs, it is rarely used for the RV and LA analysis.

In the present survey, many centres (75%) answered that 3D TTE was available in their echo lab but with consistent activity volume differences. Still, most of them used 3D TTE for the LV analysis, according to the ASE and the EACVI guidelines.[12] Similarly, in a recent EACVI survey on standardization of cardiac chambers quantification by TTE, >90% of centres had access to 3D TTE; however, most centres reserved these techniques for selected cases, particularly for measuring LV volumes and ejection fraction.[13]

Disappointingly, we found that most survey participants infrequently performed RV measurements using 3D TTE (45% of centres with the technology available). Similar data were reported in another recent EACVI survey on the multi-modality imaging assessment of the right heart.[14] This observation probably reflects the lack of dedicated software (as compared with the LV) for this assessment.

Likewise, the present survey highlighted that less than half of the laboratories equipped with the modality analysed the LA with 3D TTE. Our finding parallels the result of the EACVI survey on standardization of cardiac chamber quantification by transthoracic echocardiography, in which only 10% of centres used 3D TTE to assess LA volumes.[13]

In the present survey, 80% of centres had access to strain analysis, suggesting the wide availability of this modality in most Italian echo labs. However, most centres appear to reserve strain only for LV analysis. Indeed, it was unexpected to report that, despite growing evidence of their additional value in the literature, only 49% of the centres used RV and 48% LA strain analysis. Our observations are consistent with a recent worldwide survey from the EACVI, which highlighted how, despite the almost universal availability, only 39% of the participants performed and reported strain results frequently (>50%), which was mainly used to assess the LV (99%) and less frequently the RV (57%) and the LA (46%) function.[15]

The recent innovations and advantages of AEI are unquestionable. A growing body of evidence demonstrates the effectiveness of AEI in identifying cardiac disorders at an early stage, showing its superiority over traditional methods in terms of repeatability, timeliness, affordability, and feasibility in a wide range of clinical scenarios such as valvular heart diseases,[16] cardio-oncology,[17] immune-mediated[18] and

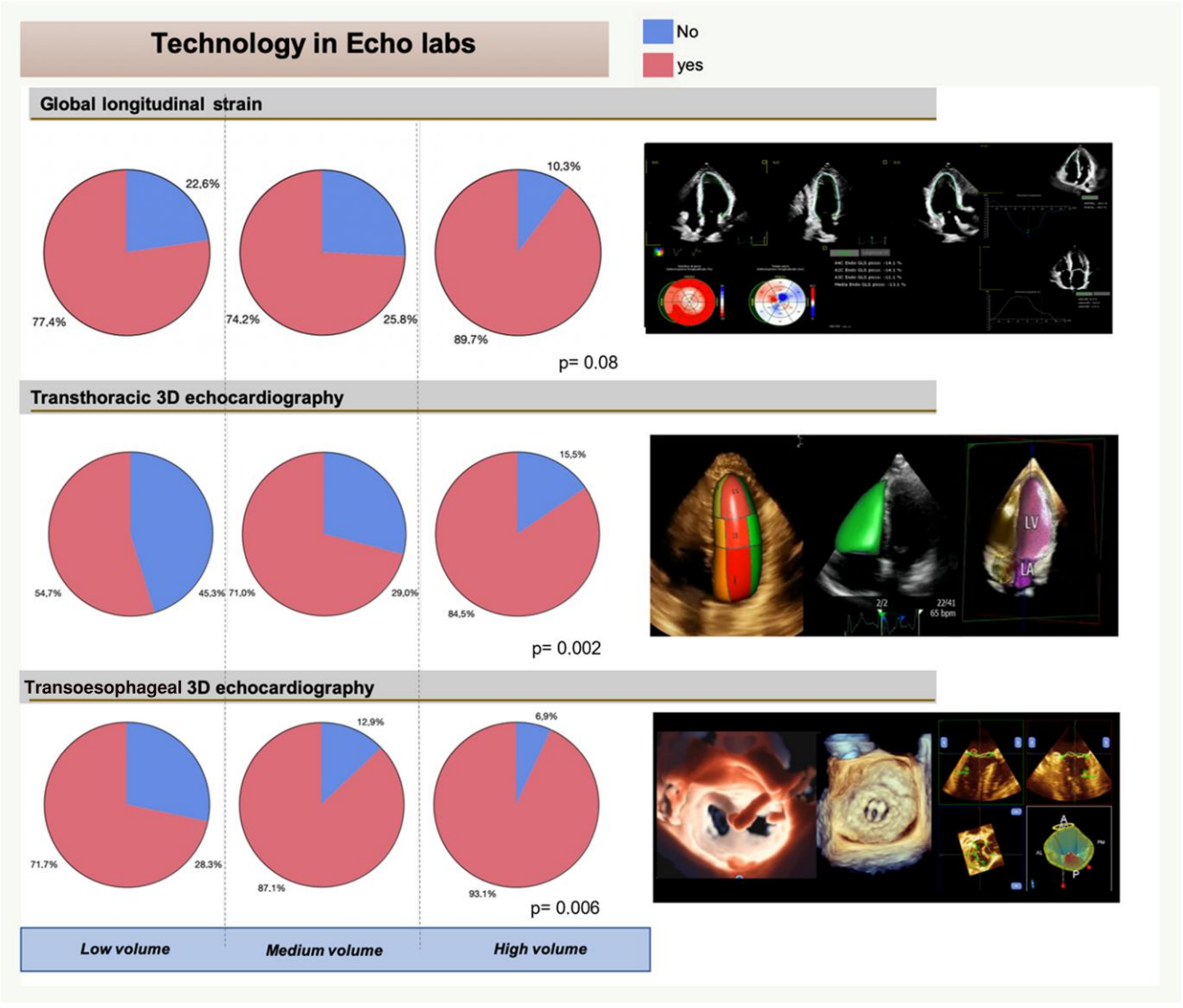

Figure 2 Advanced echocardiography imaging present in echo lab in Italy according to type (from above: strain, 3D transthoracic echocardiography, and 3D transoesophageal echocardiography). Blue, absent; red, present. *P* for statistical significance.

infiltrative diseases,[19] arterial hypertension and metabolic disorders,[20] heart failure with preserved ejection fraction,[21] hypertrophic cardiomyopathy and phenocopies,[22] acute coronary syndrome,[23] chronic ischaemic cardiomyopathy,[24] adult with congenital heart disease,[25] pulmonary arterial hypertension,[26] and acute myocarditis.[27] The proof that AEI has a place in everyday practice is indicated by its role in the COVID-19 pandemic.[28] Despite this amount of evidence, our data highlight that numerous obstacles prevent a wider spread of AEI in clinical practice. Most likely, inadequate training and time constraints are the primary reasons for not adopting AEI more frequently. Indeed, sonographers and cardiologists must be educated in image capture and analysis techniques that allow for reliable post-processing and robust results, but integrating AEI requires many other crucial resources, such as suitable equipment, patient selection, adoption of protocols into ordinary clinical practice, modification of echo lab workflow, storage, and reporting.[29] In addition, hospital administration must acknowledge and believe in the clinical usefulness of AEI and necessary billing and reimbursement adaptations, as AEI also involves a discussion around cost justification. It's also essential to define more robust reference values and standardization of values, considering that 66% of centres in the present survey use two or more different vendors within the same laboratory.[30]

Certainly, additional study is needed to determine whether AEI can enhance patient care and results. Clinical trials incorporating AEI features will be critical in identifying the most relevant and robust patient care parameters in various clinical settings. Nonetheless, the widespread adoption of AEI necessitates, first and foremost, a willingness to adapt based on the recognition that AEI adds practical value to our daily practice. Accordingly, recent data demonstrated that using AEI is timesaving compared with conventional evaluation.[31] Therefore, if AEI is not part of the routine practice yet, scientific societies should designate the inclusion of these procedures in standard transthoracic echocardiographic examinations among their responsibilities. To fulfil this objective, the SIECVI is now working to standardize

AEI acquisition, reporting, dedicated training, certification, and quality control methods across most echo labs in Italy.[32]

Study limitations

We used the SIECVI's electronic e-mail list, which includes the majority—but certainly not all—of the echocardiographic activity in Italy.[11] Some extra-SIECVI centres have high volumes and high-quality standards. However, although the survey may have underestimated the diffusion of AEI activities in selected centres of excellence, it most likely accurately reflected the quality and pattern of practice.

As with any survey, there will be non-responders for various reasons, including a lack of time or a reluctance to engage in the study. Moreover, the replies may be skewed due to the respondents' possible differing perspectives or interpretations of the questions.

Finally, no independent, external validation of the data provided by the cardiologist head of the participating echo lab was possible.[11,33,34]

Conclusions

In Italy, the AEI modalities are more frequently available in centres with high-volume activity but employed only in a few cardiac chamber applications, being more frequent in analysing the LV compared with the RV and LA. Therefore, the echocardiography community and SIECVI should promote uniformity and effective training across the Italian centres. Meanwhile, collaborations across centres with various resources and expertise should be encouraged to use the benefits of the AEI.

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Data availability

The article's data are provided by the SIECVI by permission. Data will be shared on request to the corresponding author with the permission of the SIECVI.

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