Potential for Empowering and Broadening the Application of the SART Embryo Grading System

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Introduction

Morphological assessment of embryo quality has been the method of embryo selection for embryo transfer since the very beginning of the application of assisted reproductive technology (ART) in infertility treatment (1-5). However, there is no known single morphological charcteristic available to enable a simple method for embryo viability assessment. Different grading methods have been developed and utilized in selecting embryos for transfer (6-14). The necessity of developing a unifying standard method of grading and reporting embryo quality as acceptable to all has long been recognized. The embryologists under the banner of SART (Society for Assisted Reproductive Technology) took the initiative by including embryo quality in the SART data base, establishing an embryo grading system that uses a uniform grading method by all reporting embryologists at least in the United States(15-20). The initiative was a brilliant attempt at standardizing the grading method across the SART member programs. Accordingly, in 2005, SART charged a task force for developing a grading system for the SART database (SARTCORS). This SART body developed 3-point grading system (good, fair and poor) using morphological parameters relevant to different developmental stages (15, 16). The voluntary collection of embryo data for transferred embryos using the grading system, (designated as 'SART embryo grading system', SART grading system' or 'SART system in this manuscript), was initiated in 2006 and collection of data became mandatory from 2010 (15-20).

The necessity of such a unifying embryo grading method has also been felt by the international community. The European embryologists are working toward adopting an embryo classification system similar to that of SART (21-26, 61, 62, 63). The intention behind these efforts is to produce a de facto international standard for morphological embryo grading. The SART embryo grading system has begun to draw global attention due to its inherent simplicity and predictive power. The SART system emphasized that the grading method must be simple, should have a basis in scientific inquiry with some proven predictive value and be easily adoptable in IVF laboratories of any capacity, and was intended for grading cleavage, morula, and blastocyst stage embryos (15, 16). The objective of the present study was to see if the SART grading system can be improved upon and whether it can have wider application in the field of ART. Our study found the SART method to be full of potential to become an international standard of embryo viability assessment by showing how to make it more efficient and applicable to all developmental stages of a developing embryo.

Materials and Method

Three sets of information were taken into consideration: (1) frame work of SART grading system; (2) proficiency test (PT) on SART grading; (3) published literatures on evaluation of human embryo quality.

The grading parameters of the SART grading system were reviewed. The PT data collected by the American Association of Bioanalysts (AAB) on the SART embryo grading system were analyzed (27). The AAB proficiency test analyzed the embryo grade information provided by the participant embryology laboratories on the same embryos supplied to them in the form of video images. The participants were instructed to follow the

SART reporting requirements in grading each embryo image displayed in the appropriate video.

The published literature focusing on evaluation of human embryo quality was reviewed (28-36, 57, 59, 63). Special emphasis was given to the articles dealing with morphological assessment of embryos (37-42, 56, 58). Different morphological determinants proposed in the previous embryo grading methods for evaluating developing embryos were thoroughly searched (43-48, 60, 61, 62).

Attempts have been made to find ways to accommodate some of the morphological determinants of the other reviewed grading systems into the SART system if found relevant. The possibility of applying the SART embryo grading system to all developmental stages, using additional qualitative and quantitative grading options, has been explored by developing stage specific embryo grading charts.

Results

SART Grading System

The SART 3-point grading system targeted 3 growth phases: cleavage, morula, and blastocyst (Table 1). "Good", "Fair" and "Poor" were assigned to differentiate the embryos of each of these growth phases by evaluating the phase specific relevant morphological parameters. SART used cell number, fragmentation, and symmetry for cleavage embryo; compaction, and fragmentation for morula; and expansion (size), inner cell mass, and trophectoderm for blastocyst as evaluating parameters (15, 16). The initial SARTCORS data found robust associations between embryo grade and pregnancy rate (18-20).

AAB Proficiency Test

AAB proficiency testing for embryo grading did not include day 4 morula stage. Instead, it aimed at day 1 zygote, day 3 cleavage and day 5 blastocyst stages (27). More than 140 IVF laboratories participated in the AAB proficiency test events in 2010 and 2011. The summary of the survey results is shown in Table 2. If the majority's opinion is accepted as the 'right grade' of an embryo, then in most of the PT events a good embryo is typically recognized as good and rarely as fair but never as poor. The case in identifying fair and poor embryos was similar. A few particular occasions left the embryologists confounded between good and fair (Table 2).

Table 1. SART Grading System

Growth Phase	Overall Grade	Stage
Cleavage	Good, Fair, Poor	Cell #: 1 through >8
		Fragmentation: 0%, <10%, 11-25%, >25%
		Symmetry: Perfect, Moderately Asymmetric, Severely Asymmetric
Morula	Good, Fair, Poor	Compaction: complete, incomplete
		Fragmentation: 0%, <10%, 11-25%, >25%
Blastocyst	Good, Fair, Poor	Expansion: Early, Expanding, Expanded, hatched
		Inner cell mass: Good, Fair, Poor
		Trophectoderm: Good, Fair, Poor

Source: Racowsky et al. Fertil Steril 2010; 94(3): 1152-1153 and J Assist Reprod Genet 2010; 27: 437-439

Disparity in Grading Time and Grading Methods

The literature shows that the growth phase specific post-insemination timing for grading embryos is 17-19 hours for day 1, 42-45 hours for day 2, 64-69 hours for day 3, 89-94 hours for day 4, 115-118 hours for day 5 and 140-142 hours for day 6 (17, 26, 27, 30). Grading of different developmental stages, and also the variations in the application of the different morphological determinants in grading, apparently contributed in producing multiple grading methods (30, 44, 47).

Potential Upgrades in the SART System

Taking SART grading parameters as nucleus (Table 1), attempts were made to make them comprehensive by adding more morphological determinants or introducing other changes where appropriate (Table 3). Four growth phase specific morphological parameters, instead of the current two or three, projected to be more effective in grading embryos (Table 3). As in the SART system, the same grading parameters found suitable for any cleavage stage, day 2 or day 3, and similar is true for blastocyst of day 5 or day 6 (Table 3).

The application of SART grading for all embryo growth phases, starting from oocyte (day 0) to blastocyst (day 6), was found feasible. Grading charts were developed utilizing an embryo assessment algorithm (Tables 4-7). These grading charts utilized 4-parameters based 3-point grading, and have options for qualitative as well as quantitative grading capabilities. According to this proposed grading chart, an embryo at any developmental stage (day 0 to day 6), gets one of the nine qualitative grades which can be translated into five quantitative grade scores (4, 6, 8, 10 and 12) where poor, fair, and good embryos are assigned values of 1, 2, and 3, respectively.

Table 2. Summary statistics of the embryo grading scores of year 2010 and 2011 proficiency test (PT) events.

Develop	AAB	No of	Specimen 1			Specimen 2		
stage	ID no.	Labs	Good	Fair	Poor	Good	Fair	Poor
Day 1	2011-1st	143	110 (77%)	33 (23%)	0 (0%)	69 (48%)	72 (50%)	2 (2%)
	2011-2nd	155	79 (51%)	66 (42%)	10 (7%)	60 (39%)	74 (47%)	22 (14%)
	2010-1st	119	66 (56%)	50 (42%)	3 (2%)	78 (66%)	35 (29%)	6 (5%)
	2010-2nd	126	26 (21%)	28 (22%)	72 (57%)	3 (2%)	20 (16%)	103(82%)
Day 3	2011-1st	142	101 (71%)	40 (28%)	1 (1%)	120 (85%)	22 (15%)	0 (0%)
	2011-2nd	155	122 (78%)	33 (22%)	0 (0%)	127 (81%)	24 (15%)	4 (3%)
	2010-1st	119	111 (93%)	8 (7%)	0 (0%)	93 (78%)	26 (22%)	0 (0%)
	2010-2nd	126	122 (97%)	4 (3%)	0 (0%)	7 (6%)	106 (84%)	13(10%)
Day 5	2011-1st	141	49 (35%)	87 (62%)	5 (3%)	100 (71%)	35 (25%)	6 (4%)
	2011-2nd	153	109 (70%)	42 (27%)	4 (3%)	20 (13%)	77 (50%)	56 (34%)
	2010-1st	119	55 (46%)	61 (51%)	3 (2%)	5 (4%)	67 (56%)	47 (40%)
	2010-2nd	126	14 (11%)	80 (64%)	32 (25%)	12 (9%)	50 (40%)	64 (51%)

Table 3. Characterizing growth stage specific morphological parameters utilizing the SART proposed embryo grades, and morphological determinants that used in the previous embryo grading methods including SART method.

Day 0 (1-4 hrs post retrieval) Oocyte

A. Zona pellucida
   a. Good: full satisfaction with color, size, shape, thickness and texture.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

B. Perivitelline space
   a. Good: no space or if space but of no concern, no inclusion in the space.
   b. Fair: slightly deviated from a (noticeable space with or without inclusion).
   c. Poor: considerably deviated from a (large space with or without inclusion).

C. Ooplasm
   a. Good: homogeneous, translucent, no aggregation of organelles, granularity, vacuolization, central darkness or other sign of dysmorphism.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

D. Polar body
   a. Good: single intact polar body of appropriate size and shape.
   b. Fair: slightly deviated from a (concern about size, shape or fragmentation).
   c. Poor: considerably deviated from a (substantial concern related to size, shape, fragmentation or degeneration).

Day 1 (17-19 hrs post insemination) Zygote

A. Zona pellucida
   a. Good: Full satisfaction in terms of color, texture, size, shape and thickness.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

B. Pronucleus
   a. Good: two clearly identifiable pronucliue with desired symmetry, orientation and alignment (membrane bounded two PNs of equal size, central and apposed, and nucleoli of identical numbers and sizes).
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

C. Cytoplasm
   a. Good: Satisfactory in terms of texture (smooth), color (not yellow or dark), granularity (no granules), halo, vacuole (no vacuole) and ER plaques.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

D. Perivitelline space

a. Good: no space or smaller space of no concern, no inclusion in the space.
b. Fair: slightly deviated from a (noticeable space with or without inclusion).
c. Poor: considerably deviated from a (large space with or without inclusion).

Day 2 (42-45 hrs post insemination) Embryo

A. Zona pellucida
   a. Good: satisfactory in terms of color, texture, size, shape, and sign of thinning.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

B. Blastomere number and quality
   a. Good: Full satisfaction with expected blastomere count (4±0) with stage appropriate size (zona filled, evenly sized, translucent, smooth membrane) and no sign of multinucleation.
   b. Fair: slightly deviated from a (blastomere count < 3 or > 4, and/ or multinucleation).
   c. Poor: considerably deviated from a (blastomere count ≤ 2, and / or multinucleation).

C. Blastomere symmetry
   a. Good: perfect symmetry in size and shape of the blastomeres or insignificant size differences between the blastomeres.
   b. Fair: slightly deviated from a (moderately asymmetric).
   c. Poor: considerably deviated from a (severely asymmetric).

D. Blastomere fragmentation
   a. Good: none or mild (≤ 10%) fragmentation.
   b. Fair: slightly deviated from a [moderate (11-25%) fragmentation].
   c. Poor: considerably deviated from a [severe (> 25%) fragmentation].

Day 3 (64-69 hrs post insemination) Embryo

A. Zona pellucida
   a. Good: satisfactory in terms of color, texture, size, shape, and sign of thinning.
   b. Fair: slightly deviated from a (by one or more of the relevant features).
   c. Poor: considerably deviated from a (by one or more of the relevant features).

B. Blastomere number and quality
   a. Good: expected blastomere count (8±0) with stage appropriate size and cohesiveness of the blastomeres, no sign of multinucleation.
   b. Fair: slightly deviated from a (blastomere count 6, 7 or > 8, and/ or sign of multinucleation).
   c. Poor: considerably deviated from a (blastomere count ≤ 5, and/ or sign of multinucleation).

C. Blastomere symmetry
   a. Good: perfect or acceptable symmetry in size and shape of the blastomeres, insignificant size differences between the blastomeres.
   b. Fair: slightly deviated from a (moderately asymmetric).
   c. Poor: considerably deviated from a (severely asymmetric).

D. Blastomere fragmentation
    a. Good: none or mild (≤ 10%) fragmentation.
    b. Fair: slightly deviated from a [moderate (11-25%) fragmentation].
    c. Poor: considerably deviated from a [severe degree (> 25%) of fragmentation].

Day 5 (115-118 hrs post insemination) Blastocyst

A. Zona pellucida
    a. Good: satisfactory in terms of color, texture, size, shape, and expectedly thin.
    b. Fair: slightly deviated from a (by one or more of the relevant features).
    c. Poor: considerably deviated from a (by one or more of the relevant features).

B. Blastocyst size (expansion)
    a. Good: full, expanding, expanded, hatching or hatched; no sign of black spot, arrested blastomeres, or exclusion of cells.
    b. Fair: slightly deviated from a and/ or early blastocyst.
    c. Poor: considerably deviated from a and/ or morula and embryo.

C. Inner cell mass (ICM)
    a. Good: composed of many cells, compacted, and easily discernible with no vacuoles or dark spot.
    b. Fair: slightly deviated from a (by one or more of the relevant features).
    c. Poor: considerably deviated from a (by one or more of the relevant features).

D. Trophectoderm (TE)
    a. Good: comprising many cells forming a cohesive epithelial layer (satisfactory in terms of cell number, cell size, and their distribution and texture, no fragments/ vacuoles or dark spots).
    b. Fair: slightly deviated from a (by one or more of the relevant features).
    c. Poor: considerably deviated from a (by one or more of the relevant features).

Day 6 (140-142 hrs post insemination) Blastocyst

A. Zona pellucida
    a. Good: Thin enough for hatching/ expectedly thin, sign of popping.
    b. Fair: slightly deviated from a.
    c. Poor: considerably deviated from a.

B. Blastocyst size (expansion)
    a. Good: expanded or hatching or hatched, also collapsing/expanding.
    b. Fair: slightly deviated from a and/ or full, expanding.
    c. Poor: considerably deviated from a and/ or early blastocyst, morula, embryo.

C. Inner cell mass (ICM)

    Same as defined in day 5.

D. Trophectoderm (TE)

    Same as defined in day 5.

Embryos receiving either good or poor grades, by all parameters, scored 12 and 4, respectively. Embryos achieving mixed grades of good and fair or fair and poor scored 10 or 6, respectively. Embryos with other combination of grades scored 8.

Discussion

A clinical embryologist faces two major challenges: maximizing pregnancy success and minimizing the risk of multiple births. He has to be able to select the right embryo from the embryo cohort available to him in order to achieve both the goals in one shot. This can certainly be an exigent task. Morphology based embryo selection has always been used to face such a challenge. Other methods of assessing embryo quality include metabolomics, proteonomics, and genomics which are currently under investigation but not yet clinically applicable (45, 46, 64). Even as embryo selection by different 'omics' become a reality, their utilization can be beyond the reach of many laboratories simply because of financial limitation and complexity of such technology. Perhaps based on such realizations, the continued refinement of morphological evaluation has led to the development of multiple morphological grading methods (6, 30, 47, 56, 60-63).

The SART embryo grading system is uniquely different from the others reported in the literature. First, SART grading is simple and thus easily adoptable by any IVF program. Apparently the use of simple terminologies (good, fair and poor) as grades made the SART grading straight forward without diminishing its diagnostic power. The SART organization perhaps realized that it would be easier to have a consensus in identifying embryos as good, fair or poor than by any other grading methods. Since the SART system is subjective, it relies heavily on the embryo grading skills of embryologists. Based on the PT data (Table 2), we are encouraged to speculate that over time, external PTs will act as a leveling player by bringing the evaluation skills of embryologists to a level where a good embryo will be identified as good not only by the majority but by all. Also, with the SART sponsored embryo grading guidelines and its periodic updates, following the style of ASRM practice committee reports, they may be able to effectively bring homogeneity and consistency into embryo assessment. Secondly, the grading system is

Table 4. Standardized grading chart for oocyte

Zona Pellucida

Polar Body					**Oplasm**
		G	F	P	
	G	GGGG 3+3+3+3=12	FGFG 2+3+2+3=10	PGPG 1+3+1+3=8	G
	F	GFGF 3+2+3+2=10	FFFF 2+2+2+2=8	PFPF 1+2+1+2=6	F
	P	GPGP 3+1+3+1=8	FPFP 2+1+2+1=6	PPPP 1+1+1+1=4	P
		G	F	P	

Periveteline Space

backed by a professional organization (SART) for its development and implementation. Members are obliged to apply this grading method as it is mandatory at least for reporting purposes (15-19). The information obtained from this compulsory submission of embryo data will provide an opportunity to identify its strengths as well as weaknesses so that necessary refinements can be made. The majority of grading methods lack this opportunity. Most importantly, the SART system demonstrated a promising predictive power. Evidence showing the positive impact of embryo selection using SART system on pregnancy has already emerged (18-20). The above mentioned distinctive modifications could help make the SART grading system useful to all ART laboratories without the consideration of societies or international boundaries.

Accordingly, we were inspired by such prospects for the SART system and reviewed not only its current state but have suggested useful modifications. Although the grading system was designed for cleavage, morula and blastocyst, SART most likely did not intend to restrict such grading to these phases. We have shown that the system is equally suitable for other developmental stages (Tables 4-7). The capability of a grading system to evaluate the quality of embryos in all growth stages demonstrates its augmented strength and usefulness. Time-lapse cinematography/ imaging (TLC/ TLI) has already taken a revolutionary role in documenting morphological details, eliminating the negative aspect of repeated embryo grading, as the morphology evaluation will be automated and taking embryo out of the incubator will not be necessary. TLC is able to document the cleavage time of zygotes which is also thought to have good predictive power of developmental potential. Thus by TLC technology, an oocyte's entire history (zygote to blastocyst) of in vitro growth will be electronically/digitally available to embryologists for determining the relative vivacity of individual embryos within an embryo cohort (42, 46, 48, 65). This is an ambitious but realistic goal for the near future. There are pros and cons regarding single static evaluation (snapshot) vs. multiday scoring (17, 29, 45, 46, 48). Our approach of adding grading capabilities in the SART system for all the developmental stages is not so much concerned with such debate, but is rather focused on making the SART system versatile in dealing with all

Table 5. Standardized grading chart for zygote stage embryo.

Zona Pellucida

Pronucleus	G	F	P	**Cytoplasm**
G	GGGG 3+3+3+3=12	FGFG 2+3+2+3=10	PGPG 1+3+1+3=8	G
F	GFGF 3+2+3+2=10	FFFF 2+2+2+2=8	PFPF 1+2+1+2=6	F
P	GPGP 3+1+3+1=8	FPFP 2+1+2+1=6	PPPP 1+1+1+1=4	P
	G	F	P	

Polar Body

circumstances in the foreseeable future.

This study focused on the necessity of upgrading the SART grading system. The system, introduced in 2006, has since become dated given the considerable amount of new information which has enriched the field. The time is right to upgrade the system. We have envisioned some possible improvements in the SART grades and grading parameters which may make them more robust and useful (Table 1vs.Table 3). These anticipated changes, however, do not affect the simplicity of the SART grading system. We find the justification to upgrade the SART system from the realization that more determinants and parameters in the system will make the system more powerful by introducing added prognostic power. A similar view, voiced from the recent Istanbul consensus workshop on embryo assessment, emphasized the inclusion of all of the parameters of an embryo when developing an embryo classification and scoring system (21, 58, 59, 62, 63). The 'SART grades' itself draw our attention for possible upgrade. The differences among the SART 3 grades and methods of finding such differences can be reviewed for refinement. In our view, the utmost emphasis should be given in defining the ''Good" grade in the 3-point grading system. The grade "Good" should be fixed by applying strict criteria and utilizing as many determinants as possible. This approach is equivalent to the well known use of Kruger strict criteria over WHO criteria for sperm morphology evaluation. The Kruger strict criteria concept is more applicable in embryo morphology since further discrimination among the Good embryos is essential as explained later. Our recommendation is that comprehensive but stringent criteria should be used to select Good embryos and then the degree of deviation such as 'slight' and 'considerable' can be used for identifying Fair and Poor embryo. This type of qualitative differentiating terms to scale the degree of deviation from "Good" can be similarly powerful and suitable as the SART 3-point grades are, provided the definition of "Good" is comprehensively established. This revised method of classifying the grades "Good", "Fair" and "Poor" may help in reducing subjectivity when identifying Good embryos, a group most important to all embryologists.

The recommendation of including more grading parameters was made as another possible upgrade to the

Table 6. Standardized grading chart for cleavage stage embryo.

Zona Pellucida

Blastomere Number	G	F	P	**Blastomere Fragmentation**
	G	F	P	
G	GGGG 3+3+3+3=12	FGFG 2+3+2+3=10	PGPG 1+3+1+3=8	G
F	GFGF 3+2+3+2=10	FFFF 2+2+2+2=8	PFPF 1+2+1+2=6	F
P	GPGP 3+1+3+1=8	FPFP 2+1+2+1=6	PPPP 1+1+1+1=4	P
	G	F	P	

Blastomere Symmetry

SART system. Based on these recommendations, the use of zona pellucida (ZP) as a grading parameter is justified (Table 3). Zona is an integral part of all growth phases starting from the oocyte and it is only abandoned by the embryo at late blastocyst stage for implantation. No matter how good the true embryo is, if ZP is defective or does not function properly, the embryo will be trapped causing a failure to hatch. Zona may or may not be as important as other parameters but important enough to be considered for morphological evaluation of embryos. The precise evaluation of internal parameters like blastomere number and symmetry, fragmentation, ICM and TE, may not be always be straight forward. On the contrary though, the ZP being the outer most structure is easy to evaluate with precision. With progression of the growth and developmental changes in the true embryo there is expected to be a change in the zona which is a prognostic predictor of an embryo's hatching and implantation potential (26, 40, 49-52). The significance of zona hardening, either acquired by aging or culture condition cannot be ignored. Correlation between ZP thickness and blastomere number, embryo grade, and fragmentation has also been found (49-52). There is likely more that can be learned about the zona, however, the opportunity will be lost if ZP is excluded from embryo evaluation. Taking all this into consideration, the majority of other grading methods incorporate ZP as a grading parameter except for a few as well as the SART system which falls into that minority category. We mentioned a couple of upgrades above, however, the study goal was not to propose specific upgrades but highlight its necessity.

Identifying good embryos in an embryo cohort is not sufficient. The SART grading system should aim for further differentiation of the good embryos. The presence of multiple high quality (good) embryos in an embryo pool is very common in the majority of IVF patients, probably because of improved stimulation protocols and culture systems. The grading system should have the ability to discriminate the good embryos further so that the embryos can be ranked for preferences of choice such as 1st, 2nd, 3rd, 4th, etc. In IVF practices, the number of embryos to be transferred is restricted worldwide and usually

Table 7. Standardized grading chart for blastocyst stage embryo.

Zona Pellucida

Blastocyst Size		G	F	P		**Trophectoderm**
		G	F	P		
	G	GGGG 3+3+3+3=12	FGFG 2+3+2+3=10	PGPG 1+3+1+3=8	G	
	F	GFGF 3+2+3+2=10	FFFF 2+2+2+2=8	PFPF 1+2+1+2=6	F	
	P	GPGP 3+1+3+1=8	FPFP 2+1+2+1=6	PPPP 1+1+1+1=4	P	
		G	F	P		

Inner Cell Mass

varies 1 to 3 depending on day of embryo transfer and patient parameters. Obviously, the risk of multiple pregnancies plays a role in deciding the number to be transferred to a patient. If the grading system can rank the good embryos as # 1, # 2, # 3 and so on, further reduction of the number of embryos in the transfer will be possible without compromising the pregnancy rate. In this study the grading charts were developed to implement the above recommended upgrades in the SART system and explored the possibility of further differentiating the good embryos. It is true that all morphological parameters used in assessing embryo quality do not carry the same weight (diagnostic power). The significance of a grading parameter can diminish or excel depending on the circumstances. The interdependence of the grading parameters also cannot be ignored. Keeping all these into consideration, 4-parameters based embryo assessment algorithms were utilized to develop the grading charts. This algorithm produced integrated morphology scores which allow for further differentiation between the embryos of apparently similar quality. This is possible since the charts permit finding deeper level differences between similar embryos by bringing the individual grade components into consideration. Thus, by the accumulated scores, the embryos can be designated as # 1, # 2, # 3 and so on. The grading charts can also help to determine whether a particular laboratory is able to produce satisfactory embryos. How well our embryo assessment algorithm will be able to differentiate good embryos can only be known through gathering real data. However, it certainly showed the importance of further differentiation of the good embryos of an embryo cohort.

As a side note, two observations from the literature search on morphological evaluation of human embryos caught our attention that are worth mentioning. First, information on morula morphology is very scanty and morula grading is an unpopular event. SART came up with two parameters, compaction and fragmentation, which may not be easy to evaluate and quantitate in this growth phase. Some other grading schemes found compaction followed by fourth round of cleavage as important prognostic factor for morula (26, 53, 54, 55). The second noteworthy point was that no growth phase specific fixed time is stringently followed for embryo grading. The grading time was found to vary approximately 2 to 4 hours depending on growth phase (17, 26, 27, 30). Organizational guide lines can help to adopt a more uniform grading time and, once such guidelines are followed, variation in grading outcomes among the laboratories will be diminished to some extent. In other words, adherence to stage specific set timing for grading can help to reduce the grade discrepancies that result from comparison of morphological information obtained at different time. The time of hCG injection or insemination (IVF and ICSI) can act as reference points for setting such growth stage specific grading times. In the case of insemination being used as the reference time, ICSI cases are straight forward, while IVF insemination cases will require consensus in setting strict times.

In summary, we reviewed the SART embryo grading method and found it uniquely different from other grading methods. Choosing three plain grades "Good", "Fair" and "Poor" for differentiating embryos made SART grading simple. Grading simplicity without compromising predictive power, and support of a professional organization made it powerful and unique. There is however, a scope for bringing improvement to the SART grading method. Modifications in the way SART grades are applied may reduce its subjectivity particularly in finding good embryos. The current parameters used in the SART system appear oversimplified and thus have become less exclusive. The addition of more morphological determinants and other relevant changes in the grading parameters may make the SART grading parameters more comprehensive and ultimately improve the system's predictive power. The original SART system is geared towards cleaving, morula and blastocyst stages. We find it applicable to all growth stages, oocyte to blastocyst, while identifying it as less suitable for morula. It has been shown that if growth stage specific four-morphological parameters are used in the SART system, the assessment can be more comprehensive. The present study found the necessity of further differentiation of good embryos but the current SART system lacks scope for such distinctions. It has also been realized that if a uniform grading time accepting the time of hCG injection or insemination as reference point, can be implemented then the time related discrepancies in embryo grades

among embryologists can be eliminated or at least greatly reduced. The introduction of the SART grading system is certainly a good start for developing a unifying standard method of embryo assessment. However, upgrading the system is the demand of time due to the emergence of new information and technologies in the field. The present study points out some of the possible upgrades that would serve to make the SART system more resourceful, flexible and adaptable to those choosing embryos in all ART laboratories.

Acknowledgement

A number of clinical embryologist friends provided valuable feedback comments for improving the quality of the manuscript. I extend a most sincere thank-you to them (Shampath Kotagi, Baylor medical center at Carrollton, Texas; Eduardo Sanz, center for reproductive health, Crest Hill, Illinois; Norendra Joshi, Wayne State University, Detroit, Michigan). I am also grateful to University Fertility Center, University of Texas Medical Branch at Galveston for supporting me in all aspects. ■

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