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Humanities in health

Training the eye and diagnosing the canvas in the Museum 'A perspective on art-based medical education'

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ABSTRACT

Art-based observational training in museums has the potential to enhance observational and communicational skills and to augment competences as empathy and tolerance of ambiguity. We developed and implemented art-based observational courses for residents at three central surgical training centers in collaboration with major local museums.

Groups of 6–12 residents participated in guided sessions in a museum led by an art historian and an experienced surgeon. The ABCD-method was used to structure layered examination and discussion of an artwork, supported by targeted exercises. Artworks were selected based on visual content and the possibility of depicted medical features for iconodiagnosis.

Around 150 surgical residents participated in the program. The process of observing and interpreting artworks, exchanging reflections and debating visual physical abnormalities was highly valued. Works by famous masters such as Rembrandt, Rosselli, Rubens and Vermeer were examined and discussed from medical and art-historical perspectives. Herein, three works by Rosselli, Ket and Rembrandt, respectively, are reviewed in iconodiagnostic detail. Course design and group interaction not only showed educational value but also strengthened team cohesion.

The synergy of observational training and iconodiagnosis in art-based settings enhanced the educational program. The courses were highly valued by the participating surgical residents and potentially improved their professional competencies. Our experiences support the integration of visual arts courses in surgical training. This approach may be applied in all medical disciplines.

Introduction

Art-based observational training has been employed in medical education to improve visual skills [1–5]. In surgery, we largely depend on visual information to interpret diagnostic images, physical abnormalities, and anatomical structures during procedures. Accordingly, 'training the eye' is recognized as a crucial part of learning surgical skills [6].

Art-based learning has also shown to enhance empathy and tolerance of ambiguity [7–10]. These qualities are considered valuable for clinicians in providing compassionate patient care and have been associated with improved patient outcomes [11,12]. Similarly, empathizing with the patient fosters a genuine interest in the patient facilitating personalized treatment and shared decision-making, potentially enhancing patient satisfaction and quality of care [13,14].

We have introduced an art-based observational course as part of the training program in three surgical departments in the Netherlands, working closely with three local, major art museums [7,15–17]. To facilitate structured training in observational skills, we devised the ABCD method, which offers a template for participants to critically observe artworks during group museum visits [7,18]. The method involves the layered examination of an artwork; noting observations, delaying judgment, and discussing possible interpretations within the group. The artworks used in the program were selected to include

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conceivable medical features, allowing participants to translate visual findings into a possible corresponding medical condition or situation. The association between depicted details and medical features is known as 'iconodiagnosis' [19,20,21].

During the courses, a series of artworks were critically examined and discussed in conjunction with a set of exercises. We evaluated this visual arts project among residents from the three participating surgical training centers, using qualitative and quantitative methods [7]. In this report, we focus on the iconodiagnostic aspects of the courses including several original observations. We believe visual arts courses offered within the context of a museum environment has the potential to enhance a surgical training program.

Contents of the courses

An art-based observational course was initiated by the Department of Surgery at Amsterdam University Medical Center, in collaboration with the Rijksmuseum (RM) in Amsterdam. Groups of 6–12 participants were guided through a series of artworks during a two-hour museum session, led by an art historian and an experienced surgeon. The learning objectives have been defined in a previous publication [15]. Artworks were selected based on their visual content, with preference given to those depicting conceivable physical abnormalities.

Following the successful implementation of the course in Amsterdam, the Departments of Surgery at Erasmus Medical Center in Rotterdam and Haaglanden Medical Center in The Hague also joined the project [16,17].

Surgical departments and collaborating local museums

The three participating surgical departments in this project collaborated with a prominent local museum. These museums rank among the top in the Netherlands, each housing unique art collections that attract a multitude of visitors annually. All participating departments have long-standing experiences in surgical residency training, coordinated nationally by the Netherlands Surgical Association. The participating institutions and their partner museums are:

1 Amsterdam University Medical Center, University of Amsterdam, in collaboration with the Rijksmuseum (RM) in Amsterdam. The Rijksmuseum is the largest art museum in the Netherlands, renowned for its 16th- and 17th-century Dutch paintings. Its collection includes masterpieces by Rembrandt, Vermeer and Steen, as well as works by prominent Italian artists from the same era.
2 Erasmus Medical Center, Erasmus University Rotterdam, in collaboration with Museum Boijmans Van Beuningen (BB). This museum holds a unique collection of paintings ranging from the Middle Ages to contemporary art. During the study period, the museum was closed for renovations; however, a significant part of its collection was accessible to the public at the museum's Depot.
3 Haaglanden Medical Center, The Hague, in collaboration with the Museum Mauritshuis (MM). Haaglanden Medical Center is a major regional hospital affiliated with Leiden University Medical Center (LUMC), and its surgical residency program is shared with LUMC's training program. The Mauritshuis houses masterpieces by Vermeer, Rubens, Steen, Rembrandt, and some of Rembrandt's most notable pupils. Rembrandt's iconic *The Anatomy Lesson of Dr. Nicolaes Tulp* painted in 1632, is on permanent display at this museum.

The ABCD method for structured observation of artworks

The ABCD method was used to structure the observation of artworks, combined with interactive group discussions [7,18]. During each session, the group visited 6–8 artworks. At each artwork, participants were first invited to concentrate and closely examine the piece for 1–2 min (Attention, silent observation, part A of the method).

After this initial observation, participants were asked—each in turn—to name an item or feature they had noticed in the artwork, then to describe perceived relationships between items, and finally to consider an interpretation (Behold, part B). Emphasis was placed on delaying personal judgment until all viewpoints were shared and discussed in the next phase. Guided by the art historian and clinician, the group then engaged in a moderated discussion where reflections were exchanged and summarized (Communication, part C).

Finally, a possible physical abnormality or a medically relevant feature visible in the artwork was identified and discussed in the context of a medical condition or its representation in the historical era in which the artwork was created (Diagnosis, part D).

The full ABCD method was implemented in Amsterdam (Rijksmuseum) and The Hague (Mauritshuis Museum). In Rotterdam (Museum Boijmans Van Beuningen), the Diagnosis component (part D) was included selectively, depending on the specific artwork visited.

Targeted exercises

In addition to the ABCD method, participants performed a series of exercises designed to practice observational and interpretative skills, each with a specific clinical objective. These targeted exercises formed an integral part of the workshop and supported the learning objectives [15].

Outcomes

Overall, around 300 participants comprising medical students and a variety of medical doctors engaged in the art-based courses at the three designated museums from November 2021 to October 2025. Approximately 150 of the participants were enrolled from the three surgical departments, including residents as well as supervising staff surgeons.

Evaluation of the courses

The courses were evaluated on a qualitative and quantitative basis as previously published [7,15,17]. Briefly, qualitative assessments used standardized 9-item questionnaires with three additional open questions [7]. Responses were recorded on a 5-point Likert scale. Quantitative evaluation comprised pre- and post-intervention assessments using the Tolerance of Ambiguity in Medical Students and Doctors (TAMSAD) scale consisting of 29 items, each scored on a 5-point Likert scale [7]. The paired *t*-test (SPSS) was used to analyze outcomes.

Residents responded enthusiastically to the museum-based courses [7,15,17]. They perceived art-based observation as a meaningful addition to their professional development. The practice of focused looking, verbalizing what is seen, and deferring judgment until group discussion fostered individual awareness and collaborative interpretation.

A quantitative evaluation was performed in the Amsterdam University Medical Center/Rijksmuseum cohort using pre- and post-intervention assessments. This involved validated tools for measurement of empathy and tolerance of ambiguity [7,22]. Both competences showed a statistically significant improvement following the intervention.

Iconodiagnostic findings

During the 'D' part in observing an artwork, participants considered a range of potential diagnoses based on visual clues [3,18,22–28]. These discussions were stimulated by careful observation of painted or sculpted physical features, often open to multiple interpretations. Remarkable physical features detected in the examined artworks were discussed and analyzed. As the visited artworks overall, were examined by a variety of medical professionals, not only surgeons, the final iconodiagnostic conclusions may be considered to be achieved through multidisciplinary consensus. Several surprising and original observations on the canvasses were made during the courses, not documented in

literature before.

While a comprehensive account of all iconodiagnostic findings associated with the artworks visited in the three museums falls beyond the scope of this report, a selection of discussed physical features, medical inferences and putative conditions is shown in table I. Famous masterpieces by artists such as Rembrandt, Rosselli, Rubens and Vermeer were discussed from the viewpoint of both medicine and art history. The iconodiagnostic levels of evidence as proposed by Charlier et al. were considered for each artwork as shown in table I [20]. One sample from each of the three participating museums' collections is highlighted herein (indicated in Table 1 with *):

Rijksmuseum (RM), Amsterdam: The Adoration of the Christ Child. *Cosimo Rosselli*, c.1485-1507, Florence [29].

The central part of the painting shows Mary and the newborn Christ (nativity) lying in a bundle of straws. To the left of Mary is John the Baptist with a staff ending in a cross, while Joseph appears in the background on the right. On the far left are two angels, one with both hands on John the Baptist's shoulder and the other supporting the head of the newborn Christ's head (Fig. 1).

Iconodiagnostic features

Macrosomia: The Christ Child appears large for gestational age, suggesting macrosomia. In the 15th century, however, the Christ Child was usually depicted as a small man with an adult face rather than an infant (homuncular Jesus). As symbolism turned into realism, renaissance artists depicted the Christ Child as a baby [29,30].

Down syndrome: The Child Christ shows several physical traits that can be associated with Down syndrome [31]; almond-shaped eyes with typical upslanted palpebral fissures, shortened neck and low-set ears. The right foot shows a widened space between the first and second toes, known as a 'sandal-gap'. The fingers appear short (brachydactyly). In 45% of newborns with Down syndrome, the palms of the hands show a single crease. The palm of the left hand is depicted in detail and reveals the normal double palmar crease. However, this does not exclude Down syndrome. The noticed features are characteristic of Down syndrome, which is surprising -even blasphemous- in the context of the Christ Child. Possibly, Rosselli used a newborn with Down syndrome as a model for the Christ Child for this painting. There are several examples in Renaissance paintings of the Christ Child bearing physical traits suggestive of Down syndrome, as in *Virgin and Child* by Andrea Mantegna (1431–1506) or in *The Adoration of the Christ Child* by Jan Joest of Kalkar (1450–1519) [31–33].

Babinski sign: The right foot of the Christ Child exhibits extension (dorsiflexion) of the big toe while the lateral sole of the foot is stimulated by contact with Mary's robe. This feature is consistent with the Babinski reflex, a physiological response observed in newborns up to 6 months old [28]. This phenomenon has been noted in 30% of renown Renaissance paintings.

Moro reflex: The Christ Child displays the startle reflex, which is a normal infantile response to the sensation of falling. The infant arches the back and extends arms and legs. This primitive survival instinct, known as the Moro reflex, usually fades away within 3–6 months [34]. The artist apparently captured the moment when the Christ Child's head lands in the angel's outstretched hands.

Thyroid swelling: An enlargement of the anterior neck region of Mary is apparent, suggestive of goiter. This feature has been noted primarily in Renaissance paintings, particularly in iodine-deficient areas such as central Italy, and it has been perpetuated as part of ideal beauty in young women, even when their necks had a normal appearance [22,24,27].

The level of evidence of the iconodiagnostic features described on this canvas is considered II, according to the criteria proposed by Charlier et al. [20].

Boijmans van Beuningen Museum (BB), Rotterdam: Self-portrait with red geraniums *Dick Ket*, 1932, Bennekom, The Netherlands [35].

Dick Ket was known to have a congenital heart defect (*dextrocardia* with *situs inversus*), which led to his progressive physical deterioration. In this self-portrait, he depicted his affliction with all the physical signs it

Table 1
Examples of iconodiagnostic features discussed during art-based observational training in three museums [18,23–26,32–35,37,40–42] *(The artworks indicated with * are elaborated in the text)*.

Artist	Year of creation	Depicted in artwork	Observed medical feature	Diagnostic interpretation	Level of evidence (I-IV)
Ket*	1935	Man with swollen neck veins and finger tips	Jugular vein distention, clubbing fingers	Congenital heart disease	I
Rosselli*	1495	Young woman (Mary) with swollen neck	Prominent anterior neck mass	Goitre	II
		Big newborn baby	Large for gestational age	Macrosomia	II
		Christ Child with extension right big toe	Dorsoflexion right hallux	Babinsky sign	II
Bartholomeus van der Helst	1642	Man with facial rounding, short neck, obesity	Moon face, buffalo hump, central obesity	Cushing's syndrome	II
Rembrandt	1628	Portrait of man with swollen, red earlobe	Inflamed earlobe with piercing	Infected ear piercing	II
Meester van Alkmaar	1504	Man with nose deformity	Saddle nose	Congenital syphilis	II
Meester van Alkmaar	1504	Hunched mid-back	Kyphosis thoracic spine	Pott's disease (spinal tuberculosis)	II
Unknown, France	1260	Bleeding chest wound	Thoracic wound 5th intercostal space	Thoracic wound with liver bleed	II
Anonymus, Germany	1500	Boy with asymmetric low shoulder after trauma	Sloping shoulder	Paralysis trapezius muscle due to accessory nerve injury	II
Bueckelaer	1566	Man with unusual arm posture	Internal rotation arm with flexion wrist and fingers	Erb's palsy	II
Rembrandt*	1632	Corpse with disproportionate physical features	Kyphoscoliosis, short right arm and leg	Hemiatrophia infantilis congenita	II
		Anatomical dissection forearm	Exposed muscles and tendons originate from lateral epicondyl	Superficial flexor tendons originate from medial epicondyl	I
Rubens	1616	Old woman cupping burning candle with hand	Short-sightedness with hand too close to candle flame	Diabetic retinopathy, neuropathy	II
Meester van Alkmaar	1504	Disabled man sitting on floor with hand-crutches, extra toes	Both feet rotated inwards and downwards, foot with 7 toes	Congenital clubfoot with polydactyly (PITX1 gene mutation)	I
Vermeer	1665	Girl with hair loss	Absence of hair, eyebrows and eyelashes	Alopecia areata	II

Fig. 1. The Adoration of the Christ Child. *Cosimo Rosselli*, c.1485-1507, Florence. Oil on panel, Tondo, diameter 14.5 cm. Collection Rijksmuseum, Amsterdam [29].

presented (Fig. 2).

Iconodiagnostic features

The painting shows a mirror image of the artist, with the right half of his chest partially exposed - the site of his cardiac anomaly. It displays the typical signs of cardiopulmonary disease: congested jugular veins and central cyanosis (bluish discoloration of the body), as well as typical nail clubbing (drumstick fingers and watch-glass nails). In the bottom right corner, part of a book cover is visible, bearing the word FIN in mirror lettering, alluding to the artist's awareness that the end of his life was near (FIN meaning the END) [35,36].

As the subject of the painting is known to have had *dextrocardia*, the level of evidence according to Charlier *et al.* may be considered I [20].

Museum Mauritshuis (MM), The Hague: The Anatomy Lesson of Dr. Nicolaes Tulp

Rembrandt, 1632, Amsterdam [37].

This masterpiece, created by Rembrandt in 1632, was commissioned by the Surgeons' Guild of Amsterdam. The painting depicts Dr. Tulp demonstrating the dissection of the left arm of a recently executed criminal, while the surgeons observe intently [38]. The depicted anatomy of the forearm tendons has sparked a debate relating to the anatomical accuracy of the dissection (Figs. 3 and 4).

Iconodiagnostic and anatomical features

The subject of the dissection, the corpse lying obliquely in the composition, was minutely documented in the records of the Surgeons' Guild of Amsterdam. His name was Adriaan Adriaensz, a 28-year-old man with a long criminal record who was eventually sentenced to death [38]. The body seems disproportionate, with a short neck, possibly indicative of kyphoscoliosis, and the right arm and leg appear too short. He walked with a limp and because of his misshapen demeanor, was nicknamed Aris 't Kint (Aris the kid). It has been suggested that this child-like person had a condition called *hemiatrophia infantilis congenita* [39].

In Tulp's dissection of the left forearm of the corpse, the flexor muscles and tendons are exposed. Using forceps in his right hand, he lifts the superficial flexor muscles while with his left hand, he gestures the resulting flexion of the thumb and index finger, demonstrating the function of these muscles [38]. However, the flexor muscles appear to originate from the lateral rather than the medial epicondyle, which seems to be an anatomical inaccuracy at first glance. During the courses, the residents discussed this apparent discrepancy in close examination in front of the canvas (Figs. 3 and 4). It becomes evident that Rembrandt was not mistaken: the arm is shown in an oversupinated position, which rotates the medial epicondyle forward and creates the illusion of a lateral origin. This observation was confirmed by repeating the dissection on a male cadaver at the Department of Anatomy at the University of Groningen [40].

Discussion

Experiences of observational training using visual arts

In 2021, we initiated a visual arts program at the Rijksmuseum for medical students, in collaboration with the museum's art educators. A course was subsequently tailored to medical professionals, including residents in training [15]. As the program evolved, the ABCD method was developed, establishing a consistent structure for the course using a defined selection of artworks and practical exercises [18]. Residents from the Department of Surgery at Amsterdam University Medical

Fig. 2. Self-portrait with red geraniums. *Dick Ket*, 1932, Bennekom, The Netherlands.
Oil on canvas, 80.5 × 54 cm. Collection Museum Boijmans van Beuningen, Rotterdam [35].

Center began participating regularly at the Rijksmuseum. The program was expanded to include the surgical departments in Rotterdam and The Hague, in collaboration with Museum Boijmans Van Beuningen and Museum Mauritshuis, respectively.

The three participating museums are among the most prestigious in Europe, each housing unique collections that include iconic masterpieces. Their galleries offer an ideal setting for both enhancing observational skills and strengthening interpersonal connection. The integration of a medical perspective within an art historical context made the course a distinctive and enriching experience for surgical residents. Works of famous masters such as Rembrandt, Rosselli, Rubens and Vermeer were included. Art-based observational training is now added to the residency programs of the three participating surgical departments, marking the first structured and regularly offered initiatives of their kind in the Netherlands. This setup can be replicated in any surgical department in collaboration with a local art museum and also can be used in the training of other healthcare professionals.

Similarities between VTS and the ABCD method

Visual Thinking Strategies (VTS) is a methodology that was developed in art museums and has since been adopted for use in art-based medical education [41,43]. VTS was used in visual arts workshops at the Museum of Fine Arts in Boston, and showed to improve observational and problem-solving skills of surgical residents [44]. In preliminary stages of our project, we used VTS in our museum sessions after the first author had completed a VTS certification course for art educators.

We modified the method to mirror the clinical approach to a patient: first observing the details, then putting these together, ultimately leading to a conclusion. The VTS and ABCD methods share similarities in that they are both based on close and critical observation, focusing on visual details. The ABCD method begins with silent observation (A). The group leaders then paraphrase the observations (B) and encourage the group to discuss their findings (C) in the same way as with VTS. A difference is that the VTS method starts with the question 'What's going on in this picture?', whereas the ABCD method reaches that point at the conclusion of the group discussion, mirroring the process of presenting a patient in a clinical meeting. The extra question is the probable diagnosis (D) in the picture based on the observed details. Critical observation, listening and comfort with ambiguity are key elements in both methods. The original VTS framework may be preferred for senior doctors, who, based on their long-standing clinical experience, immediately recognize physical features in a picture that are associated with a diagnosis. They then dissect what they see into the details of their observation leading to an interpreted discussion.

The iconodiagnostic puzzle

The synergy of observational training and iconodiagnosis, discussing a medical feature in an art-historical context, enhanced the educational value of the program. Artworks for the courses were selected specifically for their inclusion of visual elements suggestive of medical conditions or features. As the courses continued, new iconodiagnostic features were also discovered upon examination of the canvasses.

Whether depictions of a medical feature were intentional by the artist or merely coincidental remains open to debate. Renaissance artists, for example, often sought realism, capturing minute physical details and imperfections in their subjects even if those details may have been less esthetic [27,28].

For instance, an undersized arm in a painting, shown in internal rotation with extension and pronation of the forearm, accompanied by a flexed wrist and fingers, can be interpreted as depicting Erb's palsy, a condition resulting from brachial plexus injury during childbirth [25]. However, the appearance of the arm may have been created using visual foreshortening or perspective, as devised by the artist, rather than an intention to portray a pathological state. This ambiguity emphasizes the importance of collaborating with art historians who are familiar with the specific artwork and the stylistic concepts typical of the artist who created it.

Evaluation of the courses

Evaluations showed that residents responded enthusiastically to the museum-based, visual arts courses. The engagement and discussions during the courses encouraged an open environment, in which no observation was considered right or wrong [3].

The process of group interaction - interpreting artworks, exchanging reflections and performing practical exercises - was reported to enhance team cohesion. In this regard, the course functioned not only as an educational session but also as a team building activity, strengthening interpersonal bonds among residents as well as between the residents and their supervising surgeons.

Educational impact

Whereas the added value of art-based medical education is increasingly recognized in the field of medical humanities, art-based learning has scarcely been applied in surgical training programs [6]. This is in part due to the lack of objective outcome measures with which to assess art-based education. Since the medical profession relies on

Fig. 3. The Anatomy Lesson of Dr. Nicolaes Tulp. *Rembrandt,* 1632, Amsterdam.
Oil on canvas, 216.5 × 169.5 cm. Collection Museum Mauritshuis, The Hague [37].
The photograph shows a group of residents from Haaglanden Medical Center attending a course at the Museum Mauritshuis (MM) in The Hague. The discussion focusses on Rembrandt's anatomy painting depicting the dissection of the left forearm.
(Photograph by author TMvG).

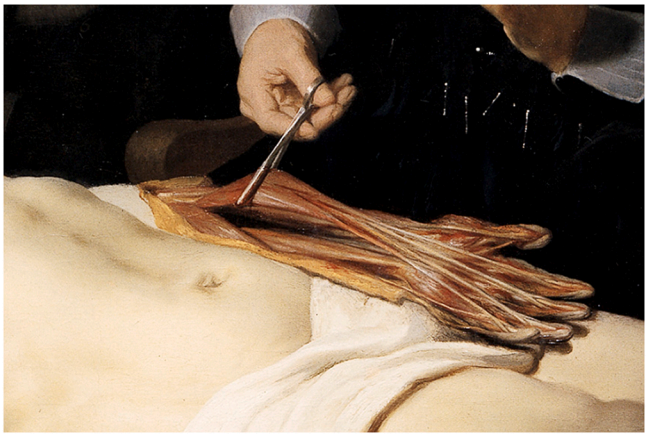

Fig. 4. Detail of the photograph of Fig. 3, showing the anatomy of the dissected forearm in Rembrandt's Anatomy lesson of Dr. Nicolaes Tulp.

evidence-based data, to quantify the educational impact of art-based observational training, consequently, remains challenging [45]. Validated instruments to assess observational and cognitive competencies are difficult to apply in this setting. Nevertheless, in earlier studies, we employed the Jefferson Scale of Empathy (JSE) and the Tolerance of Ambiguity in Medical Students and Doctors (TAMSAD) scale to assess outcomes among a mixed cohort of healthcare professionals [7,45–47]. These studies demonstrated significantly improved post-course scores for both empathy and ambiguity tolerance. Improvement on the TAMSAD scale, suggests that the training enhanced participants' capacity to manage uncertainty, a skill that may contribute to greater cognitive flexibility and resilience in surgical practice.

We are currently developing an extended program in which residents participate in a series of sequential art-based learning interventions. This design allows for pre-assessment across multiple competencies, as well as mandatory post-interventional testing upon completion of the program. This approach enables residents to train their observational skills through repeated learning experiences over time.

Conclusion

Visual literacy is an essential skill in surgical practice. Training surgical residents through structured visual arts sessions in museum settings was highly valued and enhanced professional competencies. Layered observation and discussion of a selected series of artworks, combined with iconodiagnostic elements, provided a reproducible format for the courses. The program, supported by targeted exercises, can be offered in any medical training setting in collaboration with a local art museum. We strongly encourage the integration of visual arts courses as a valuable addition to surgical training. This approach may be applied across all medical disciplines, particularly in visually-oriented specialties such as dermatology and radiology.

Ethical declarations statements

This study did not involve animal or human subjects.

The authors therefore, have no related ethical declarations to declare.

Ethical Approval

N/A.

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Declaration of competing interest

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References

[1] Dolev JC, Friedlaender LK, Braverman IM. Use of fine art to enhance visual diagnostic skills. JAMA 2001;286:1020–1. https://doi.org/10.1001/jama.286.9.1020.

[2] Naghshineh S, Hafler JP, Miller AR, Blanco MA, Lipsitz SR, Dubroff RP, et al. Formal art observation training improves medical students' visual diagnostic skills. J Gen Intern Med 2008;23:991–7. https://doi.org/10.1007/s11606-008-0667-0.

[3] Smydra R, May M, Taranikanti V, Mi M. Integration of arts and humanities in medical education: a narrative review. J Cancer Educ 2022;37:1267–74. https://doi.org/10.1007/s13187-021-02058-3.

[4] Mukunda N, Moghbeli N, Rizzo A, niepold S, Basserr B, DeLisser HM. Visual art instruction in medical education: a narrative review. Med Educ Online 2019;24:1558657. https://doi.org/10.1080/10872981.2018.1558657.

[5] Cerqueira AR, Alves AS, Monteiro-Soares M, Hailey D, Loureiro D, Baptista S. Visual thinking strategies in medical education: a systematic review. BMC Med Educ 2023;23:536.

[6] Cohen SM, Dai A, Katz JT, Ganske IM. Art in surgery: a review of art-based medical humanities curricula in surgical residency. J Surg Educ 2023;80:393–406. https://doi.org/10.1016/j.jsurg.2022.10.008.

[7] Bult SA, van Gulik TM. Empathy and tolerance of ambiguity in medical students and doctors participating in art-based observational training at the Rijksmuseum in Amsterdam, the Netherlands: a before-and-after study. J Educ Eval Health Prof 2025;22. https://doi.org/10.3352/jeehp.2025.22.3.

[8] Kumar AM, Lee GH, Stevens LA, Kwong BY, Nord KM, Bailey EE. Using visual arts education in dermatology to benefit resident wellness and clinical communication. MedEdPORTAL 2021;17:11133. https://doi.org/10.15766/mep_2374-8265.11133.

[9] Bentwich ME, Gilbey P. More than visual literacy: art and the enhancement of tolerance of ambiguity and empathy. BMC Med Educ 2017;17:200.

[10] Slavin R, Williams R, Zimmerman C. Activating the art museum. Designing experiences for the health professions. New York / London: Rowans & Littlefield; 2023. ISBN 9781538158548.

[11] Han JL, Pappas TN. A review of empathy, its importance, and its teaching in surgical training. J Surg Educ 2018;75:88–94. https://doi.org/10.1016/j.jsurg.2017.06.035.

[12] the Collaborative Orthopaedic Educational Research Group, Sabharwal S, Lin C, Weistroffer JK, LaPorte DM. Empathy among orthopaedic surgery trainees. JBJS Open Access 2021;6:e21.00041. https://doi.org/10.2106/JBJS.OA.21.00041.

[13] Niburski K, Guadagno E, Abbasgholizadeh-Rahimi S, Poenaru D. Shared decision making in surgery: a meta-analysis of existing literature. Patient 2020;13:667–81.

[14] Machin M, Van Herzeele I, Ubbink D, Powell JT. Shared decision making and the management of intact abdominal aortic aneurysm: a scoping review of the literature. Eur J Vasc Endovasc Surg 2013;65:839–49.

[15] De Ruiter PE, Van de Brug B, Reijntjes MA, Linsen L, Lagarde S, van Gulik TM. Art-based observational training for medical students and surgical residents in two Dutch museums. Clin Ter 2024;175:101–9. https://doi.org/10.7417/CT.2024.5040.

[16] Bult SA, de Ruiter PE, van Gulik TM. See better by looking at art, visual training for medical students and doctors at the Rijksmuseum, Amsterdam. Tutor 2025;24. https://doi.org/10.13135/1971-8551/11320.

[17] van Gulik TM, Huizing F, Bult SA, Leijdesdorff A, de Mol van Otterloo A. Observational and iconodiagnostic training for surgical residents in Museum mauritshuis in the Hague. Tutor 2025;24. https://doi.org/10.13135/1971-8551/11305.

[18] Van Gulik TM, Bult SA, De Ruiter PEJ. Evaluation of the ABCD-method in art-based observational training for medical students and surgical residents in the museum. Int J Surg Educ 2024. https://doi.org/10.5281/zenodo.14838239.

[19] Franco V. Icono-diagnosis: a challenge between medicine and art. Senses Sci 2019;6:747–52. https://doi.org/10.14616/sands- 2019-6-7477.

[20] Charlier P, Perciaccante A, Kluger N, Nerlich V, Appenzeller O, Donell ST, et al. Iconodiagnosis: guidelines and recommendations. Ethics Med Public Health 2023;31:100951. https://doi.org/10.1016/j.jemep.2023.100951.

[21] Van Gulik TM, Bult SA, Crijns M. The Seven Works of Mercy; a 16th century Dutch picture gallery of skin disease. J Eur Acad Dermatol Venereol 2025. https://doi.org/10.1111/jdv.70243. Epub ahead of print. PMID: 41342090.

[22] Sterpetti AV, Fiori E, De Cesare A. Goiter in the art of Renaissance Europe. Am J Med 2016;129:892–5.

[23] Bianchi DW, Scherjon SA. Medical findings and congenital anomalies in Vermeer's paintings. Am J Med Genet 2024;194A:e63583. https://doi.org/10.1002/ajmg.a.63583.

[24] Clark ZC, Clark OH. The remarkables; Endocrine abnormalities in art. Perspectives in medical humanities. University of California Press; 2011. ISBN 987-0-9834639-0-0.

[25] De Ruiter PE, Bult SA, Dijkstra JR, van Gulik TM. Erb's palsy: visual diagnosis in art before medical history? Gynecol Obstet Invest 2025;28:1–10. https://doi.org/10.1159/000546120.

[26] Bult SA, De Ruiter PE, Vergroesen PA, van Gulik TM. Erb's Palsy. Orthopaedic portrayals in The Seven Works of Mercy painted by a Dutch master in the year 1504. Int Orthopedics 2025;49:2733–9. https://doi.org/10.1007/s00264-025-06653-06657.

[27] Accorona R, Huskens I, Meulemans J, Cappelli C, Nicolai P, Lombardi D. Thyroid swelling: a common phenomenon in art? Eur Thyroid J 2018;7:272–8.

[28] Sellal F, Tatu L. The Babinski sign in Renaissance paintings – a reappraisal of the toe phenomenon in representations of the Christ Child: observational analysis. BMJ 2020;371:m4556.

[29] Collection Rijksmuseum, Amsterdam, Public domain. https://id.rijksmuseum.nl/200107955.

[30] Steinberg L. The sexuality of Christ in Renaissance art and in modern oblivion. JSTOR 1983;25. iv+1-198+204-222 (218 pages), www.jstor.org/stable/778637.

[31] Skotko BG. Can a Christ child have Down syndrome? Am J Med Genetics 2021;187:213–5. https://doi.org/10.1002/ajmg.c.31895.

[32] Stratford B. Down's syndrome at the court of Mantua. Mat Child Health 1982;7:250–4.

[33] Bukvic N, Elling JW. Genetics in the art and art in genetics. Gene 2015;555:14–22. https://doi.org/10.1016/J.GENE.2014.07.073.

[34] Stokey PJ, Ravi S, Ebraheim NA. Moro reflex: a mini review of literature. J Clin Surg Res 2022;3:1–2. https://doi.org/10.31579/2768-2757/035.

[35] Collection Museum Boijmans Van Beuningen, Rotterdam, Public domain. https://www.boijmans.nl/en/collection/artworks/2128/self-portrait.

[36] De Haas WHD. Dick Ket. Een schilder en zijn ziekte. Neth J Med (NTvGeneesk) 1984;128:2423–5.

[37] Collection Museum Mauritshuis, The Hague, Public domain. https://www.mauritshuis.nl/en/our-collection/artworks/146-the-anatomy-lesson-of-dr-nicolaes-tulp.

[38] IJpma FFA, van de Graaf RC, Nicolia J-PH A, Meek MF. 'The Anatomy Lesson of Dr. Nicolaes Tulp': from a group portrait to a true Lesson in functional Anatomy. ANZ J Surg 2009;79:496–7.

[39] Lindeboom GA. Medical aspects of Rembrandt's anatomy lesson of doctor Tulp. Janus 1977;64:179–203. PMID:11610173.

[40] IJpma FFA, van de Graaf RC, Nicolai J-PA, Meek FM. The anatomy lesson of Dr. Nicolaes Tulp by Rembrandt (1632): a comparison of the painting with a dissected left forearm of a Dutch male cadaver. J Hand Surg Am 2006;31:882–91.

[41] Zheng D, Yenawine P, Chisolm MS. Fostering wonder through the arts and humanities: using visual thinking strategies in medical education. 2024. Acad Med 2024;99:256–60. https://doi.org/10.1097/ACM.0000000000005519.

[42] Van Rosmalen JM, Van Gulik TM. The Wounds of Christ and Prometheus - Two of a Kind?; 2022 Hektoen International; 2022. hekint.org/2022/03/15/the-wounds-of-christ-and-prometheus-two-of-a kind/.

[43] Ferrara V, Franceschini A, Morlacchetti R, Giannini L, Iacobini M. The visual art to improve skills for pediatrics staff. Int J Pediatrics Child Health 2023;11:22–5. https://doi.org/10.12974/2311-8687.2023.11.04.

[44] Cohen SM, DiGiovanni-Evans B, Ganske IM, Katz JT, Kent TS. Sewing the SEAMs: surgical education in the art Museum. J Surg Edu 2025;82:103401. https://doi.org/10.1016/j.jsurg.2024.103401.

[45] Ike JD, Howell J. Quantitative metrics and psychometric scales in the visual art and medical education literature: a narrative review. Med Educ Online 2022;27:2010299. https://doi.org/10.1080/10872981.2021.2010299.

[46] Hancock J, Roberts M, Monrouxe L, Mattick K. Medical student and junior doctors' tolerance of ambiguity: development of a new scale. Adv Health Sci Educ Theory Pract 2015;20:113–30.

[47] Van Gulik TM, Bult SA, De Ruiter PEJ, Huizing F, De Mol van Otterloo A, Leijdesdorff A, et al. observational training for surgical residents using visual arts in the museum. Surgery 2025;190. https://doi.org/10.1016/j.surg.2025.109843.